SCHOOL SCIENCE AND MATHEMATICS

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MEET OUR SPEAKERS!

The Central Association is indeed fortunate to have scholars of international recognition on its convention program.

Dr. B. J. Luyet has agreed to leave his research laboratory at Saint Louis University School of Medicine, where he is Professor of Biology, to tell us about some "Adventures at Low Temperatures." Dr. Luyet holds the degree of Doctor of Science in both Natural Science and Physics. His research studies have been concerned with analysis of growth, physical structure of living matter, physical properties of cellular constituents, mechanism of death, diagnosis of cellular death, and biological effects of low temperatures and high pressures.

Dr. E. R. Hedrick is well known to mathematics teachers because of his work in advanced calculus and also because of his prominence in mathematical organizations. Dr. Hedrick was for many years Professor of Mathematics at the University of Missouri and from there went to the University of California at Los Angeles to take a similar position. Recently he was named Provost and then Vice-President of that school. A fine mathematician and a very busy educator is giving generously of his time when Dr. Hedrick addresses our meeting on "Science, Ethics, and War."

"History without Generals" is the subject which *Dr. C. C. Furnas*, Associate Professor of Chemical Engineering of Yale University uses for his talk. Dr. Furnas has been at Yale since 1931. He came there from the United States Bureau of Mines and had had other teaching and commercial experience. He has come into prominence recently through the publication of his book, *The Next Hundred Years*, and his marked interest in the improvement in science teaching.

The Saturday morning general session opens with an illustrated lecture on the "Coming of Man" by *Dr. Fay-Cooper Cole*, Chairman of the Department of Anthropology at the University of Chicago. He has conducted three expeditions for the Field Museum in the Philippines, Borneo, British Malaya and the Dutch East Indies. For six years he was a special

investigator for the Philippine Bureau of Science. Since 1924 he has been associated with the University of Chicago in his present capacity. He has conducted extensive research in Mississippi Valley Anthropology and is author of numerous papers relating to the study of Man and is co-author of others among them *The Nature of the World and Man, The World and Man as Science Sees Them, The Making of Mankind, The Long Road, The Story of Man* and *Rediscovering Illinois.*

DR. FAY-COOPER COLE, Chairman of the Department of Anthropology, University of Chicago will open the Saturday morning session with an illustrated lecture on the "Coming of Man."

Following Dr. Cole's talk, the Saturday morning program will be divided into four sections. The Elementary School program will have an "Information Please" on questions of elementary science. The authorities will be *S. R. Powers,* Professor of Natural Science, Columbia University; *C. W.*

Croxton, Professor of Biology, Saint Cloud Teachers College, Saint Cloud, Minnesota; *Ira C. Davis*, Director of Science, University Training School, Madison, Wisconsin; *Rose Lammel*, Assistant Professor of Natural Sciences, Ohio State University, Columbus, Ohio. This will be followed by a panel discussion on questions which arise in the teaching of arithmetic. *Dr. Charles A. Stone*, Professor of Education, De Paul University, Chicago, will act as chairman. The others on the panel are *J. T. Johnson*, Head of the Mathematics Department, Chicago Teachers College; *Butler J. Laughlin*, Principal, Lindbloom High School, Chicago; *Harry O. Gillet*, Principal, University of Chicago Elementary School.

"Trends in Junior High School Mathematics" will be discussed by *Dr. Raleigh Schorling* before the Junior High School Section. Dr. Schorling was principal of the Lincoln School of Teachers College, Columbia University from 1917–1922 and principal of the University High School, University of Michigan from 1922–1927. Since that time, he has been with the latter university in the capacity of Professor of Education. Dr. Schorling is well known in mathematics circles through the fine textbooks of which he is co-author. His talk will be followed by one on "Catching Vitamins on Fish Hooks" by Dr. Frank B. Kirby. Dr. Kirby is a Doctor of Medicine and an experienced speaker. In addition to lecturing from coast to coast for Abbott Laboratories, which he represents as Director of Education, he is a member of the lecture staff of the Illinois Medical Association and the National Safety Council.

Head of the Department of Education at State Teachers College, Mayville, North Dakota, *Dr. George Skewes* is particularly interested in maintaining the scientific method in the teaching of science. We have asked him to talk on that subject to both the Junior High School Section and the Junior College Section. He is author of *Directed Studies in General Science*, a book of junior high school level and has taught the so-called survey courses in junior college.

The values of the Demonstration Laboratory as opposed to those of the traditional laboratory work will be discussed in a talk on the two year physical science course at the University of Chicago by *Dr. Selby Skinner*, Assistant Professor of Physical Science at that university. This talk will be given before the Secondary School Section. *W. O. Smith*, teacher of mathematics in South High School, Cleveland, will discuss the Social Arithmetic course offered in the first year of senior high school in that city. The program will be completed by an illustrated lecture by *Sam Campbell*, Philosopher of the Forest, on "The Human Side of Nature."

In addition to the talk by Dr. Skewes, mentioned above, the Junior College Section will hear a discussion of "Scientific Knowledge and Human Action" by *Dr. Joseph Schwab*, Instructor in Biology at the University of Chicago. Dr. Schwab received the award for "Excellence in Teaching" at that university in 1938 and was special consultant for the Progressive Education Association in the summer of 1939. "Modern Views about the Structure of the Universe" by *Dr. Frank K. Edmondson* of Indiana Uni-

versity completes this program. Though still a very young man, Dr. Edmondson has had scientific papers published in many important astronomical journals. His recent work was concerned with the rotation of the Milky Way system of stars and he is now engaged in a program of work on the colors of faint stars to get information about the material in interstellar space.

Most of the speakers on the Friday afternoon section programs were introduced in the October issue of this Journal. We should like to present at this time, *Dr. A. C. Ivy*, Professor of Physiology and Pharmacology at Northwestern University, who will speak to the Biology Section on "The Relation of the Endocrine Glands on Growth and Learning." Dr. Ivy is author of more than four hundred papers dealing with researches he has conducted on the alimentary canal, liver, uterus and endocrine glands. He is president of the American Physiological Society and vice-president of the American Gastroenterological Association and member of the editorial board of several other professional organizations. Among his recent publications is *The Experimental Production of Intersexuality in a Mammal.*

Miss Katherine Pfeifer will bring the view of the class-room teacher to this section in her talk "The Biology Club as a Chapter of the Junior Academy." Miss Pfeifer is a teacher of Biology in Soldan High School, Saint Louis, Missouri. She was a member of the recent curriculum revision committee in that city and has been very active in the Junior Academy Science in Missouri. Dr. Luyet, a speaker on the general program, will address the Biology Section on "Biological Organization and Cell Theory." "Science for Leisure Time" will be discussed by *Mr. Dean Stroud*, a science teacher in the Amos Hiatt Junior High School of Des Moines, Iowa, before the General Science Section. Mr. Stroud took a delegation of pupils to the organization meeting of the Iowa Junior Academy of Science in 1932. His General Science Club has sent delegates and exhibits every year since and has been awarded recognition for seven consecutive years. In 1939, Mr. Stroud was elected permanent secretary of the Iowa Junior Academy.

A licensed pilot, aircraft and engine mechanic, *Willard James Combs* is serving the faculty of Drake University as Coordinator for the federal government pilot training ground school. Pilot Combs served for some years as director of a government approved ground school and later as Director of Aeronautics in the Des Moines Public Schools. He will speak on "The Flying Telephone."

Donald D. Pettit, Staff Lecturer and Supervisor of Practice Teaching in the Physical Sciences, State University of Iowa, will talk on "The Content of Junior High School Science." Mr. Pettit is author of papers concerned with methods of teaching science, content of Junior High School science courses, science clubs, class-room equipment for teaching science and organization of teachers as a means of improvement in science education.

"Development of a Unit of Work in Elementary Science" will be demonstrated by *Gladys Forler*, teacher and consultant of Elementary Science in Shorewood, Wisconsin. Miss Forler is author of the science units used in

the fourth, fifth and sixth grades of the Shorewood Schools and the Astronomy Unit of the Unit Lesson Series published by Teachers College, Columbia University. She was co-author of *Primary Children Experience Science*, a summary of which appeared in the June issue of SCHOOL SCIENCE AND MATHEMATICS. "How Shall We Correlate Science with other Subjects?" will be answered by *Miss Rose Lammel* on this same program. Miss Lammel is Assistant Professor of Natural Sciences at Ohio State University. She instructs in the University Training School and is a member of the National Science Committee.

Dr. Gerald Craig, Instructor in Science in the Horace Mann Elementary School and Associate Professor of Natural Sciences, Teachers College, Columbia University, will address the Elementary Science group on "Does Elementary Science Teach Children to Think?" Dr. Craig has been adviser in curriculum work in many states and is now a member of the state committee in elementary science in New York State. He is a past president of the National Association for Research in Science Teaching and also of the National Council for Elementary Science. He is active in A.A.A.S. and other science organizations. He is author of many books, recent among them *Science for the Elementary Teacher* and the revised edition of *Pathways of Science*.

A complete program of events of the convention will be found elsewhere in this issue.

MARIE S. WILCOX, *President*

NATIONAL OBSERVANCE OF BOOK WEEK

"Approximately one-third of the American people are without library service," the U. S. Office of Education emphasized in commenting on the importance of the national observance of Book Week, November 12–18. The Library Service Division of the Office of Education urges school and library participation in special Book Week activities and programs.

Modern educational methods cannot function without books, the Office of Education points out. Furthermore, it suggests that it is particularly important during Book Week for schools and libraries to plan programs which will stimulate special interest in the use of books by children, and the opportunity of owning and enjoying books the year round. Boys and girls might dress up and act the part of characters they read about in books. Young people might make dioramas of dramatic scenes from books they have read. During the week there may be specially arranged book exhibits.

Emphasizing the need for a library in each school, the Office of Education reports a wide selection of reading and reference books for children, since approximately 1,000 children's books are published each year. It suggests that supplementary reading material may make school studies more interesting and meaningful to children. Reference books which are authoritative, and have the information children need, are essential in every school, and if boys and girls do not learn to use books and read with enjoyment during school days, it may mean that books will never be necessary to them, the Office of Education warns.

USING AND PREPARING A MATHEMATICS EXHIBIT

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One of the best ways to stimulate an interest in mathematics, both for parents and for children, is to put on a mathematics exhibit. Such a stimulation is essential for parents because in the last analysis, they are the ones who control boards of education. Much of the disfavor in which mathematics has recently fallen, could have been avoided if parents had been made to realize that a lack of mathematical training meant a crippled education for their children.

For children the construction of models for an exhibit does many things. Out of the four basic desires of childhood, the desires for affection, security, recognition, and new experiences, it satisfies the last two. It satisfies the desire for recognition because anything that a child does which attracts the attention of others satisfies that desire. This is particularly so, if his creation is on exhibition. The desire for new experiences also is satisfied in that he has created a material object out of what was only a mental picture before. Furthermore the physical work performed on wood, cardboard, gypsum and other materials, satisfies the same craving that makes handicraft so popular with all ages.

The most useful function of model making is the aid it gives to visualization. It is true that a fair percentage of children can solve originals in geometry mentally, and can outline the solution of an algebraic problem without recourse to paper and pencil. A very large part of the present high school population, however, cannot do this naturally. The construction in space of the parts of a problem enables a child to associate material and mental objects. It may be that, when a similar problem arises, the visual perception may be only a memory of the concrete construction of the former problem. Nevertheless it is a mental picture and that at least is an excellent start toward visual imagery.

One of the inducements to begin model making or the construction of charts and diagrams is to put on an exhibit. Here a number of questions arise such as "What shall we exhibit?" "How can we make models?" and "How can we get interest aroused?" Considerable aid in answering these questions has

come from the experiences of the mathematics teachers in the Chicago area.

For the past two years, through the kindness of the Director of the Adler Planetarium, there has been placed on the first floor of that building a mathematics exhibit. This exhibit is is prepared by schools within a forty mile radius of Chicago. Every three months it is changed as new schools participate. It is sponsored by the Womens Mathematics Club of Chicago and the Vicinity, and by the Mens Mathematics Club of Chicago and the Metropolitan Area. It is managed by a joint committee from these clubs.*

The experience of this committee is that with a few exceptions, many problems which worry teachers about putting on an exhibit will solve themselves if handled properly. Take for instance the question of what to exhibit. The most competent persons to decide this question are the pupils themselves. They are the ones who are to profit and their interests are more like those of the general public than are those of the teacher. It is true that their suggestions for models may be much simpler than those of their instructor, but the trouble with many mathematics teachers is that they are too sophisticated. They feel that exhibits must be grand and glorious things that overawe the spectator. Such is not the case. If the spectator is overawed he gets the feeling that mathematics is difficult. That confirms his suspicions of the subject. If on the other hand he gets some understanding of the meaning which the model is trying to convey, and if in addition he sees for the first time a new truth or a new point of view, he is correspondingly grateful. It must always be remembered that the public and that includes parents, do not have the same comprehensive knowledge of mathematics that teachers of the subject do, and that it is easy to get beyond their ability. The level of the general public in mathematics is not much above the seventh grade if it is that high. Therefore if a child decides to make a model, no matter how simple it may seem, let him do so. Maybe after the first model is made, the child may see that it does not have value and may decide to make a better one. In any case it is the child

* This committee is composed of Miss Laura E. Christman, Senn H. S., Chairman; Miss Marie Graff, Englewood H.S.; Miss Frances Hubler, Tilden H.S.; Miss Dorothy Martin, Bloom Township H.S.; Dr. Ruth Mason, Wright Jr. College; Miss Mildred Taylor, Fenger H.S.; Mr. Glenn Anderberg, Bloom Township H.S.; Mr. Charles E. Jenkins, Foreman H.S.; Dr. William C. Krathwohl, Armour Institute of Technology; Mr. Francis Runge, Evanston H.S. and Mr. Joseph J. Urbancek, Wilson Junior College.

himself who has made the decision, and this is good teaching. It may also be that the very simplicity of the model combined with clever craftsmanship may make an artistic appeal which satisfies a different objective. At least here is an opportunity to tie up mathematics with other subjects. Some of the exhibits at the Planetarium have been of lace, conventional floral designs and of snowflakes. One school even showed pictures of babies, apples and steel mills. In every case the fact was emphasized that here was geometry at work.

One high school had just the opposite experience with regard to making a simple model. When the students at this school were asked to take their turn at putting on an exhibit at the Planetarium, some of the boys suggested that they make a model of the Outer Drive Bridge, and show how some of the calculations used in its construction were just plain high school algebra. Their instructor was very skeptical. He could not see how boys so young, could construct such a difficult model. The boys, however, insisted that they could, so being a wise instructor he told them to see what they could do. Much to his surprise his students made such a fine model that the committee kept it on exhibition for six months instead of the usual three. This goes to show that when it comes to selecting subjects, teachers sometimes underestimate the capabilities of their students.

The question of how models can be made can also be left to the judgment of the children themselves. While the tendency at present in schools is not to offer handicraft as an option, nevertheless the desire to make things still persists in every child. This desire is frequently satisfied out of school by organizations such as the Y.M.C.A., boy's clubs and camps. Because the child gets the information away from school he prizes it all the more highly. Boys and girls especially the younger ones are eternally making things. Their ingenuity is a constant source of surprise to their elders. This does not mean that the teacher should not give helpful suggestions. Rather it means that the suggestions, if necessary, should be given in such a way that the students think they were the ones who made the decision. This also is good teaching.

Where there is no natural interest in model making, such interest can be aroused through the spirit of competition. One way is to show a model made by the teacher and ask the class if they think they can improve on it. Of course it is assumed in this case that the teacher does not possess a Jehovah complex.

Another way is to call attention to a model or a chart made by another class either in the same school or in a different school and ask if any member of the class can duplicate or make a better model. The spirit of competition and the desire to maintain prestige play a much greater role in the learning process than many people believe. The desire to acquire knowledge is not done so much for the sake of knowledge itself as it is to compete with others. It is sometimes helpful to arouse interest by saying that the child may put his name on the model and if the model has sufficient merit, it will be kept in a permanent collection and shown to other classes. It is true that it is difficult to get a start, but once it is obtained, interest increases like a snowball until the fad wears itself out. In a few years a new group of students appears, and then the entire process can be repeated.

In setting up the exhibit one of the most common mistakes is to make use of reading material which is too difficult to read because the letters are too small. Every bit of information whether it is the name of a model, a description of an object, or the explanation of a proof, should be done in letters so large and so heavy that the inscription can be read ten feet away by a person wearing bifocal glasses. The annoyance and extra effort of having to stoop, peer closely or strain one's neck to examine an inscription defeats the object of the exhibit. Many people will not even take the trouble to read such inscriptions and no one can blame them. It is needless to say that every model should be plainly marked and all explanations should be as far as possible in words of one syllable. An unmarked model or one that does not make itself plain is to the uninitiated just a waste of good material and labor.

Another factor which aids greatly in the success of an exhibit and helps to stimulate interest is a generous use of colors. Blacks and whites may be more dignified, but they are also more dismal. Gorgeous reds, oranges, blues and greens, if they do not clash, radiate happiness and cheerfulness. Mathematics can be made a cheerful subject. Advertisers long ago found the effectiveness of color advertising to be so far superior to plain blacks and whites, that they gladly paid the increased costs. Only a few educators and school teachers have yet to find out the remarkable teaching help which colors give. The proper use of colors aided by blacks and whites not only will attract attention in general to an exhibit, but can be used to

clarify a figure and to point out much more effectively than words can do, those parts to which it is desired to direct particular attention.

The keynotes of a successful exhibit are simplicity, ease of observation and attractiveness. This does not mean that bizarre and unique models should be eliminated. Rather it is wise to practice good showmanship and occasionally surprise the spectator. In a recent exhibit, a chart which attracted the most attention was one showing the probability of drawing a hand composed entirely of hearts in a game of bridge. Although unique and difficult to the average layman, the designer of the chart aided in its appeal by stating the reasoning as simply as possible. She used letters one inch high and an eighth of an inch in thicknesses, so that it required no effort to read the printing from the aisle. It attracted attention because it afforded some comfort to that large group of people who are not naturally good bridge players.

Summary. Model making is a valuable teaching aid in that it satisfies some of the fundamental desires of childhood and assists children to visualize.

Children usually have much more ability to select models and to make them than their teachers give them credit for.

Interest can be aroused through the skillful use of competition and the maintenance of prestige.

The keynotes of a successful exhibit are simplicity, ease of observation and attractiveness.

ALAND ISLANDS IN BALTIC IN SPOTLIGHT

The Aland Islands, named by some forecasters as Europe's next likely trouble spot, are the Gibraltar of the Baltic.

Long a bone of contention among neighboring countries, the Alands rise out of the sea 15 miles west of Finland and 25 miles east of Sweden. Incidentally, the name Aland is pronounced either Oh-land or Au-land.

Now a part of independent Finland, the islands in the past have been shifted, along with Finland, from Swedish to Russian rule. When Finland gained independence in 1917, an Aland Island situation arose, due to the majority of the islanders being of Swedish descent and voting to secede and go with Sweden rather than remain with Finland. It took the League of Nations council and a special commission to smooth out the tension and establish the islands as part of Finland, giving them virtually autonomous government.

Highly desirable as a military base, the islands have remained unfortified except for one brief interlude in their history. The League of Nations convention in 1921, which gave them their present status, forbade militarization.

THE ROLE OF PHYSICS IN PREMEDICAL TRAINING*

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To teachers of physiology, perhaps more than any others in medical schools, it is apparent that there is a certain amount of undesirable deficiency in the preparation of medical students in the subject of physics, possibly not so much in the content of knowledge as in lack of ability to make intelligent use of such knowledge in the biological aspects of medicine.

Whether this deficiency can be charged to any particular factor or to a variety of factors is the first question which has prompted me to undertake this discussion.

The second question is, if responsibility can be determined what remedy can be proposed?

It is not the purpose then to criticize but to inquire. If inquiry elicits any definite information then it would seem to be in order to try to work out a cooperative program that would correct the apparent difficulty.

In an effort to get some basic information, inquiries have been directed to a number of students as to their reactions. The reply of one of them is fairly typical. It was noted that he was an earnest, diligent student, mature and poised, and possessing a high scholastic record. Yet at times he showed a lamentable lack of ability to apply relatively simple physical principles to his laboratory work despite the fact that his transcript showed that he had received an excellent grade in physics.

When pressed for an explanation he replied: "Premedical physics was presented to me by an instructor who either knew nothing of biological applications of physics and consequently taught it from the point of view of an engineer, or he did not consider it worth while to explain biological applications. He never suggested any application that interested me. I thought it was just one of those things to be done and forgotten as quickly as possible."

I do not know whether this charge can be substantiated, or if so, how generally it applies to instructors in premedical

* Presented in a symposium at Springfield, Illinois, May 5, 1939 before the Physics Teacher's Association and the Section on Physics, Illinois Academy of Science.

physics. Then, too, it must be recognized that such statements may possibly fall in the category of excuses for the lack of interest. In such a case an instructor may have felt a certain sense of helplessness in trying to arouse interest.

Again it must be recognized that the degree of knowledge displayed a year or two after completion of a course is in no sense an adequate measure of either the efficiency of instruction or the student's response at the time.

This is a frank acknowledgment that the animus for my original interest in this question may not be well founded. However, most instructors in the fundamental medical courses, will, I believe, agree that the student would profit by the inculcation of a slightly different orientation of viewpoint in regard to the applications of physics in biology.

Electrophysics: Probably the most pressing need lies in the field of electricity. The applications in clinical medicine will be left to my colleagues. In the physiology laboratory, acquaintance with the basic principles of the induction coil is of paramount importance.

These principles and the differences between the induced and galvanic current are seldom clear in the minds of students, yet these differences are the foundation of electrotherapy. The instrument itself is used extensively in the laboratory for the purposes of stimulating tissues such as nerve and muscle. For this purpose it is often necessary to use the so-called single induced shock when it is desired to limit the stimulus sharply in time. There is usually some confusion, however, among the students about the relative intensities of induction by closing and by opening the primary circuits; also most students fail to appreciate the fact that there is no induction while the primary circuit is closed. Not infrequently students are found connecting battery current to secondary poles or inserting a key in the secondary circuit and attempting to control the stimulus thereby. It is true that extensive, simplified and detailed directions are included in laboratory instructions but these are seldom appreciated enough to enable the student to proceed without considerable coaching.

When it becomes necessary to use a galvanic current it is just as difficult to make clear the principle of the non-polarizable electrode. Equally puzzling is the use of rheostats for grading the intensity of the stimulus. The Wheatstone bridge and similar resistance systems then require a vast amount of explan-

ation. One of the most important applications of galvanic currents in biological work is based on the fact that in the region of the cathode irritability of any tissue is increased while in the region of the anode irritability is depressed.

Closely allied are the factors involved in ionic transfer, the development of action potentials, and their interpretation. This last point is of special importance in the study of conduction in nerves and in the heart, where the cathode ray oscillograph, the electrocardiograph, and the polyelectrophysiograph have assumed so much importance.

Almost invariably students express great surprise and even incredulity when first told of the existence of action potentials in living tissues. Although both Volta and Galvani worked on this problem 150 years ago, apparently almost no attention has been devoted to the phenomenon in the undergraduate teaching of physics.

Nearly every issue, when stimulated by any method displays a negative potential to unstimulated areas. This phenomenon appears to be preliminary to the specific activity of the issue. Thus the wave of negativity that passes over a muscle appears to precede by a very minute interval the actual contractile process. In the action current of the heart this interval may be as long as 20 sigma.

The action current of nerve has proven of inestimable value in the study of the nerve impulse, its rate of transmission, some of its biological characteristics, its relation to other processes, brain waves, etc. For the study of these phenomena, the electrocardiograph, the cathode ray oscillograph, the polyelectrophysiograph and the electroencephalograph have been developed to a high degree of accuracy. The discussion of the results of the use of such equipment is a legitimate inclusion in every standard textbook of physiology and has been for many years. That the principles involved in their use is within the scope of comprehension of the student is apparent from the fact that most of them can give a fairly lucid explanation of the principles of radio. One is, I believe, not unreasonable in asking whether it is too much to expect that, at least, the students have called to attention the existence of such a phenomenon as the action potential of living tissue. You as physicists will have to answer the question, however.

The significance of electrical resistance as a biological phenomenon also has come to assume considerable importance in

medicine and should receive more emphasis in preliminary training.

A moderate comprehension of thermodynamic principles is likewise desirable in view of the fact that oxidative processes play such a prominent role in living organism. The problem of control of heat production and heat loss is one of great importance to both the student and the physician. The determination of the basal metabolic rate involves knowledge of gas laws and of vapor tension, which most students are obliged to relearn.

Every muscular contraction produces two phases of heat production, one involving oxidation, the other being due to non-oxidative processes. The separation of these two phases was accomplished by the use of delicate thermocouples. This was an important step in elucidating the intricate processes of muscular contraction and ultimately led to the conception that oxidation is not, *per se*, involved in the process of contraction but only in the process of recovery and the preparation for the next contraction.

The escape of heat from the surface of the body obeys definite physical laws but that possibility is apparently never thought of by a considerable portion of the students.

Water transfer and regulation relate to the processes of osmosis, diffusion and filtration which occur in absorption from the intestine, secretion from glands, urine flow, lymph formation, blood composition, edema and hemolysis.

Surface tension and surface activity have long been recognized as important factors in the behavior of the cell, yet the fact appears to come as a surprise to most students.

In the consideration of the dynamics of the circulation the student is at once confronted with Poiseuille's law relating to the flow of liquid through a tube. If he is unable to comprehend this law, he will have great difficulty comprehending the modifications necessary in the circulatory system with its variable volume, irregular tubes, its extensive branching, its variable gravity factor, the pulsating character of its motor drive, and finally, its susceptibility to rapid modification by reflex influences.

The form of the pulse wave and its modifications under various conditions of physiological activity or pathological change are wholly determined by the physical principles governing the flow of liquids through tubes.

Comprehension of the physical principles of evaporation, permeability, barometric pressure, heat loss, etc., is necessary in any study of adaptation of a living organism to environment. This phase of physiology has come to assume enormous importance in relation to industrial medicine in recent years and is destined to become even more important in the future as a progressively greater proportion of the population becomes adapted to environmental conditions that depart from what one may call "natural" conditions, as in air conditioning.

In the study of the physiology of vision it is always necessary to spend a disproportionate amount of time in refreshing the students' comprehension of the principles governing transmission and refraction of light. The same is true of the principles of sound transmission in relation to the physiology of the ear.

In view of the importance that ultraviolet light has come to assume in medicine it would seem not impossible that brief reference might be made to the production of erythema or inflammation by certain limited regions of the spectrum, to antirachitic activation in other regions, to the production of fluorescence and artificial radioactivity.

In the study of respiration it is necessary to understand gas laws, partial pressures and absorption coefficients.

In the blood itself many physical factors are involved, such as the Donnan phenomenon in relation to colloid osmotic pressure, viscosity, permeability of cellular elements, and simple osmosis and diffusion. For example, it is well known that after hemorrhage blood pressure will not be maintained if the fluid volume is restored by infusion of a salt solution. But if the latter is rendered more viscid by the addition of a biologically inert colloid then a satisfactory result will follow.

Since protoplasm is colloidal in nature the principles of colloid activity are of vast importance in the study of edema and its accompanying phenomena. Somewhere in his preliminary training the student should have some thorough grounding in knowledge of factors such as the influence of acids and alkalies on the imbibition of water by colloids. This field, however, probably belongs more specifically to physical chemistry rather than to physics.

The dynamics of locomotion and the principles of leverages might be stressed more than is usually done, not only for the study of anatomy, but as well for application to orthopedic surgery and to the general functioning of the skeletal system.

Even in obstetrics this comes into play in the rotation of the head of the fetus as it passes through the birth canal.

Muscular contraction is largely a physical problem. The modern concept of this process depends largely on the work of a well trained physicist who applied his knowledge to physiological research. While it cannot be said that the problem of muscular contraction has been solved, there is little prospect of solution or of applying solution unless more men of similar training undertake this type of investigation.

The intrinsic adaptation of heart action to altered demand is a physical problem well understood, thanks to the efforts of investigators who based their approach on comprehension of its physical nature.

Enough attention should be given to radium so that the student may at least comprehend the difference between radium and radium emanation.

Occasionally, the field of medical science is immeasurably enriched by the invasion of individuals who first acquired special training in some branch of physics. To these we owe our knowledge of many important phenomena such as thermodynamics of muscle, respiration and electrocardiography.

On the other hand we find many examples of men whose primary training was in some phase of medicine but who found themselves confronted with the necessity of acquiring specialized knowledge of physics for the solution of some problem. Thus a young medical student conceived of the use of the X-ray and the Wood screen for study of the movements of internal organs. The result is the modern fluoroscope.

A physiologist saw the imperfections in the older methods of registering blood pressure so he called upon existing knowledge of physical principles to evolve a new instrument of great importance until superseded by a still more practical method.

In short there is a great field of application of physics which has been developed, mainly, not by the physicists themselves but by the biologists. Few of the conventional textbooks of physics make any definite reference to this field. It is not the intention to blame anyone for this. The only point is, whether the continuation of this situation is desirable and if not what can be done to bring about a better integration of the two aspects

It is recognized that heretofore the only outlet for physics lay in the various field of engineering. It seems perfectly proper, then, that illustrative material used in teaching should be

drawn from those fields. Perhaps there are practical difficulties in the way of such illustrations from the biological fields but at present the author sees no important reason for the apparently studied avoidance of all reference to biophysics other than custom.

There is, however, an entirely open mind on the point and a welcome for any suggestion as to what to do, if anything. It is certain, however, that medical students have grown steadily more antagonistic toward premedical physics, wherever taught. Unless some rearrangement is possible it is not unlikely that the professional schools will be compelled to revert to the practice of 25 or 30 years ago when compact, well-organized courses in physics, organic chemistry and physical chemistry were taught in the medical schools themselves and just as is now done in pharmacy schools where a pre-professional college course is not required for entrance. There are many objections to this, which were responsible for abandonment of the plan in the first place. The chief reason is that it will add greatly to the cost of a medical course since, in order to maintain a high standard of instruction an entire new department must be added to the already over-crowded medical curriculum as well as a separate set of equipment.

It seems likely that there may then be a still further separation between the more conventional aspects of physics and biophysics. I cannot accept the view that this would be desirable.

After all of the above was written there came to attention a report of the Educational Committee of the American Physical Society written in 1922. After covering much of the same ground already presented in this paper, the Committee made two important comments both of which are quoted:

"This outline is intended to be suggestive. Any attempt to catalogue the manifold inter-relations between physics and medicine in a thorough and complete fashion would attain the proportions of a volume. The ideal to keep in mind, in preparing a student to apply physics to the problems of medicine and biology, is not that he be given special facility in this or that branch of physics, which may seem to be a definite relation to a particular phase of his subsequent work. The aim should rather be to teach the subject in sufficient generality and with sufficient thoroughness to enable the student at any time to extend his knowledge along any special branch of physics his later work may require. No one can tell what the medicine of even 1930 may be like. Science grows and changes and the prospective scientist must be so trained that he may be able to grow and change. Who could have foreseen in 1880 the lines along which physics would be advancing in 1920? Who knows but that the medical student of 1940 may be guided in his theories of life phenomena by a theory of atomic structure so

far perfected as to be of great service in the contemplation of the complex problems of biology?

"It is hardly to be expected that students preparing for medical study or even for a career of investigation in biological fields will, at the present time, undertake anything like the preparation of physics which would be regarded as suitable for a prospective investigator in physics. In chemistry, the preparation of the present-day biologist is often as good as that of any professional chemist. This is as it should be, for the enormous importance of chemistry in biological investigations has been demonstrated. That physics may be able to furnish the biologist (and the chemist also for that matter) with most powerful methods of research, theoretical as well as experimental, is beginning to be recognized. The demand for increased training in physics will eventually come from the students themselves. When it does, the amount need be limited only by their ability to assimilate and use it. It is necessary that teachers of physics should be aware of the many points of contact between their subject and that of the biologist, and that workers in both fields should see to it that students are made aware that physics for the biologists is no academy luxury, that it is a necessity, of which, perforce, he will be unable to secure enough, and of which he should secure so much as will enable him to obtain a foothold and advance by his own efforts, when time and opportunity shall have indicated to him along what line of physical theory and technique he will find most assistance in the biological problems he undertakes to solve. . . .

"The attempt to provide better instruction in physics for medical students, whether in school, college, or the medical course, leads to a dilemma, between what appears to be the urgent need of more adequate preparation and serious objection to any further lengthening of the medical course. A distinguished professor of clinical medicine says that a student in his classes should have a preparation in physics and mathematics equal to that which must precede a graduate course in physics. An equally noted professor of physiology thinks that it would be easier to teach an electrical engineer the medicine necessary for a study of physiology than to teach the present medical graduate the necessary physics. Opposed to these are the statements of wise and experienced authorities on medical education who urge that the requirements for a degree in medicine are already too high: that they deter men from entering the profession. It has been stated that the number of medical graduates is less than the loss by death and retirement, but accurate statistics gathered by the Council on Medical Education of the American Medical Association prove that this is not the case. The lack of physicians in country districts appears to be a question of distribution rather than total numbers; and the remedy is to be sought in improvement in the conditions of country practice rather than the medical curriculum.

"Assuming that it would not be advisable to increase the total requirements beyond the present standards of the best medical schools, more time for physics must be sought by lessening that allotted to some other study, but here also the outlook is not encouraging. The doctor, like the lawyer and the clergyman, should be a man of liberal education, to broaden his understanding and sympathy with his patients and to command their confidence. His profession is rooted in the classics by history and terminology and he needs modern languages to keep up his progress. Institutions which require two years of biology might perhaps reduce this amount, in view of the fact that the medical school can meet a deficiency in this better than one in physics. It is also possible that there is unnecessary repetition of similar details in the first course of chemistry and that this work might be condensed with advantage. The relief from these changes would, how-

ever, be small, and though they were suggested by medical educators of high standing and experience, they were opposed by others who felt that the doctor is resorting too much to the laboratory, and getting out of personal contact with his patients. They feared that greater emphasis on physics in the curriculum would lead to an over-estimate of the value of physical instruments in medical practice. Such a tendency might be avoided if the emphasis in the course in physics for medical students is placed on the teaching of pure physics as a basis for the medical sciences, rather than on any narrow technical application."

One can take no issue with the statements as they stand. As I see it the only point is whether it is possible to impress upon the premedical student the fact that these things *really are* important. If one bears in mind the importance of illustrations in fixing basic principles, it would seem that the student could be impressed immeasurably by the simple process of including in the course of physics some demonstration of a few of the principles that have been discussed. For instance, the action current may be illustrated very simply and with no additional equipment. A few references here and there to other biophysical phenomena should involve no particular difficult for any physicist possessing a little ingenuity.

SUMMARY

The general lines along which teachers of premedical physics have proceeded appear to be sound but more reference to biological applications and more illustrative material would be desirable. More than ever before the student needs basic knowledge of physics (1) as a tool to be used in acquiring special knowledge of bodily functions: (2) as a basis for comprehension of future progress, (3) for protection against the ingenuity of the charleton such as those who developed and promoted the therapeutic use of the Abrams machine and the Ionaco horse collar, (4) for application to diagnostic methods, (5) and lastly, for the small number who will enter the research field to use in devising better methods of approach to the many problems yet unsolved.

For instructional services in America's schools, for supplies, repairs, new buildings, and equipment for 1 year, there is an approximate expenditure of $2,659,000,000. The Office of Education points out that this is less than 10¢ a day for each person of voting age in the United States.

HIGH SCHOOL BIOLOGY—ITS OPPORTUNITY

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The subject of biology now occupies a high position in the field of secondary education. Without question biology is increasing in favor among those people who are responsible for directing the curricula of our high schools. Not only are more schools offering this subject, but in schools where it has been offered, it is being made a part of the individual course of more pupils. These facts mean that the general purposes and objectives which have been set for biology are highly valuable and highly attractive. Among these valuable and attractive objectives are the improvement of personal and community health, the understanding of the life and growth of plants and animals, the appreciation and enjoyment of living things, the knowledge of and preparation for specific occupations, and the development of worthwhile hobbies. Because of its nature biology is well fitted for furthering the development of the high school pupil along these and other extremely valuable lines. As we think of these general objectives it is readily seen that biology has a wonderful opportunity for contributing to the necessary general education of each pupil in the secondary school. Although this opportunity is being fulfilled to a certain extent, there are a number of ways in which the subject is not making a very satisfactory use of its great opportunity. It is the purpose of this article to point out some of the ways in which the opportunity is not being used, and to suggest other ways in which biology can fulfill more completely its high major purposes.

It is not suitable to suggest additions to the course without first making room for these additions. In other words, in order to make room for some desirable improvements and additions in biology, it is first necessary to remove the material which offers little help in meeting the major valuable aims. Too often new material is forced into already overcrowded courses of study and into textbooks without the necessary adjustments being made. It is always desirable to examine critically the subject content of our courses in order to sort out those materials which appear of little value in the light of present standards. As a result of such a critical examination the part of this article immediately following suggests the type of material which should be removed from the biology course. The conclu-

sions here stated, as to what constitutes deadwood in the biology course, have been formed after a great many contacts with low, medium and high ability pupils; with teachers of biology; with many others who have attended or graduated from college; with medical students and doctors; and after careful examination of courses of study and textbooks in current use in the teaching of biology.

Subject Material to Remove

The college influence on high school biology is still too great. This college influence is an unsatisfactory condition which high school biology teachers have recognized for some time, and although much progress has been made in turning high school biology away from the effects of the college influence, our high school courses are still based too greatly upon material handed down from college botany, zoology, physiology, and comparative anatomy. As previously indicated biology teachers have recognized this fact and have made modifications in their courses, but the biology textbooks have followed rather slowly. In other words, biology textbooks for high school use still show the college influence very strongly. Now there is nothing wrong with this college influence just because it is a college influence. The thing that is wrong is that this college influence is what makes the high school biology course tend towards the abstract, the purely scientific, and the non-functional material which most emphatically does not belong in a course that has so much potential worth for all high school pupils. Even the college preparatory aim for a biology course, which is offered usually in the tenth year of high school, should be practically forgotten, since probably not more than fifteen percent of the tenth year pupils in high school ever begin college.

In continuing this article the impractical, non-functional nature of the college influence is described in somewhat greater detail as suggestions are given for the removal of certain types of material from the high school biology course.

Remove the large quantities of unimportant detail. There is a pronounced tendency to describe in considerable detail many minute forms of plant and animal life when, as far as nearly all of us are concerned, the differences and the particular characteristics of these various forms are of little importance either from the standpoint of use or from the standpoint of interest. Much of this material is purely scientific in nature, that is, no real use for the information has as yet been found. It is very

puzzling that such information finds its way into courses and textbooks meant for fourteen or fifteen year old pupils. Perhaps the reason is that science constantly wishes to explain all that is known about a subject, or that authors of textbooks dislike to be criticized by some fellow teachers who point out with considerable glee that such and such information has been omitted probably because the author did not know it. Whatever the reason the result is the same and we find in the biology textbooks considerable quantities of the following kind of information:

1. Species of ferns, lichens, mosses, and flowering plants found only in the Arctic regions. Naturally it is a part of a well rounded education to know that some Arctic plants may differ from those found in more favored parts of the world, but there seems to be little reason why the names and descriptions of several such species should be a part of the high school biology course being studied by pupils who have very little knowledge of, let us say, the nature and varieties of wheat.

2. Definition of such terms as paleontology, taxonomy, euthenics, ecology, etc., which are seldom used more than once throughout the course and seldom encountered in the general reading of educated adults.

3. Discussion of nearly every cell part that has ever been discovered. In this connection it does not seem very sensible to confuse what may well be the pupil's first real idea of a cell by naming and defining vacuoles, nucleolus, centrosphere, chromomere, plastids, centrosome, etc. All too often the pupil is so busy attempting to memorize these definitions and descriptions that he fails to get any very clear idea of what a cell really is. Perhaps with twice the labor he may get half as complete understanding.

4. Very similar to item 3 is the diagramming and describing of a number of steps in cell division as spirem stage, equatorial plate stage, disaster stage, dispirem stage, etc.

5. Details of structure and life of such microscopic forms as spirogyra, protococcus, diatoms, paramecium, cyclops, stentor, rotifer, euglena, volvox, nostoc, oscillatoria, etc.

6. Such information as the naming and labeling of twenty or more organs in the crayfish, and a type of information illustrated by "A clam has three pairs of nerve ganglia."

Remove many of the difficult scientific names. Closely allied with the types of subject material just indicated for removal is

the tendency to give scientific names to a great many uncommon forms of life and even to detailed structures of these forms. This tendency is another example of the effect of college methods and subject materials, and is also an example of the procedure which emphasizes pure science information. These methods are all right for college instruction but there is no place for them among fifteen year old pupils in high school. It is granted that the study of biology requires a biological vocabulary but surely it is not necessary to make high school biology a whole new language! Without question biology has many more new words than high school chemistry does, and in chemistry there is considerable association that the pupil can make between these new words in order to help him remember them. In biology very little of this kind of association is possible for the pupil. Instead, the remembering of the scientific terms used in so much of biology is about equal in difficulty and value to memorizing a lot of nonsense syllables.

If one could find some good reasons why so many long scientific names must be included as a part of the high school biology course, then there might be some justification for the extra burden they put upon the pupils. The fact that so many of these names are never met again in the lives of the big majority of high school pupils, and the further fact that many of them occur only once in a biology book indicates that they are not very valuable words even for a strictly biological vocabulary. Also when these words are checked with vocabulary lists prepared for the general use of people in much more advanced stages of education than are high school pupils, these terms are generally found missing. Following are a few of these terms selected hurriedly and meant to serve only as meager illustration of the number and kind of thing that should be removed: Drawing and labeling of the tarsus, tibia, and femur as parts of a grasshopper's leg! Isn't it sufficient that grasshoppers have legs? Again it much be realized that this illustration is not just a single minor occurrence in biology, instead it is only illustrative of mandibles, maxillae, and palpi as mouth parts; of the ommatidium as a part of a compound eye; and of thysanura, odonata, orthoptera, hemiptera, siphonaptera, mesophyll, monocotyledons, parenchyma, phloem, xylum, thallophytes, coelenterates, echinoderms, teleostei, elasmobranchii, hyphae, mycelium, chlamydomonas, closterium, etc., etc., etc.

These are the terms which are almost certain to be over-

whelming to high school biology pupils, because such terms come at the pupils in great numbers, and because these terms are almost certain to be entirely new to the pupils, and equally certain to be forgotten shortly after a test. As a matter of fact, the checking of test papers shows that most of these terms are forgotten before the tests, or are not learned at all, or if they are learned after a fashion, they are mispronounced and misspelled by the pupil—and not infrequently by the teacher also.

Remove most or all of the remaining material on classification. Perhaps one should be unusually kind to this subject of classification because without doubt it has lost much in favor in the last few years. However, since one should never speak unkindly of the dead, perhaps also one should not write too unkindly of the almost dead.

It is readily granted that there can be a good deal of pleasure obtained by a few individual pupils in working with the classification of insects and flowers for example, and here is exactly where classification belongs. That is, classification should be used as extra work for a few individual pupils who are able or interested. It does not have enough general value to be presented to all pupils in detail. By all means give the exceptional pupil an opportunity to develop along this and other special lines by furnishing him additional reading suggestions and particular problems of his own. Happily this subject of classification has largely disappeared from the usual biology courses as they are actually taught, but it still occupies too prominent a space in written courses of study and in the textbooks. Let us remove it in these spots as well as in actual teaching.

Change the usual organization of the biology course. The usual organization of the biology course is wrong. For reasons not entirely clear it has been assumed that the proper way to understand the simple general operation of the human body is first to study all of the variations in all of the lower animals from the one celled ones on up. The college influence is very apparent here because this procedure is the careful logical step-by-step method of reaching a final major aim. In answer to "Why study this?" questions by resisting pupils, high school biology teachers for years have been saying that we are studying the digestive system of an earthworm because later that will help us to understand the digestive system of man. Such an idea is ridiculous, because it was the digestive system of man

which helped us to understand the digestive system of the earthworm in the beginning of the cycle. Surely it is much simpler and much more satisfactory to spend time in the study of the digestive system of man, and then to say later (if there is any reason why we should) that the digestive system of an earthworm resembles that of man. It is a good guess that those people who know most about the digestive system of man as far as making use of their knowledge is concerned (namely the doctor specialists in gastro-intestinal disease) are very unlikely to know a tenth as much about the digestive system of an earthworm as appears in the usual high school biology course. And yet these men also probably used valuable time in studying the earthworm first. The earthworm's digestive system is only one illustration of the thing that is done over and over again with the circulatory system and the nervous system of various other lower animals before we dare mention the fact that man has blood vessels and a brain. Thus the whole organization of biology as it is usually presented is exactly reversed.

Remove the extensive chemical actions. Extensive chemical actions stated as chemical equations, and even the use of structural formulas of representative protein molecules have no place in high school biology. These equations and formulas are used in describing chemical changes which take place in digestion and in the growth of animals and plants. Hardly a pupil in high school biology will have any background which will enable him to understand these reactions, because high school chemistry nearly always follows biology by one or two years, and because the equations and formulas are not infrequently more difficult than those used in high school chemistry courses. It is difficult to understand why such material should ever have found its way into a high school course.

In summarizing the ideas presented thus far in this article it may be concluded that with few apologies or explanations we should remove material of the following sort from the high school biology course:

1. Life histories and detailed descriptions of many plants and animals of negligible importance.
2. Very minor structural details of flowers, of seeds, of microscopic plants and animals, of insects and other small animals—especially the scientific names of these parts.
3. Details of classification of plants and animals.
4. Many minor details of the body structure of man, which

structures become of value chiefly in medical school some six or seven years later.

5. Dependence upon the nervous, respiratory, and digestive systems of insects, earthworms, crayfish, and other small animals for information about the human body.

Nearly all biology teachers and probably most of the authors of high school biology texts know that pupils can learn and understand only a few of these things mentioned for removal, but the books continue to be filled with them italicized for emphasis. The extensive use of most of this type of information, together with the use of many long scientific terms, are things built up by custom with no reasonable educational basis and much possible harm. The use of extensive information of this type is a good example of the commonly repeated statement "One can't see the forest for the trees." The "trees" in this case are the endless scientific terms which the pupil is so busy trying to remember and spell that he completely misses the major biological principles, the major biological principles being the "forest."

Subject Material to Substitute

There is excellent material to substitute for that removed. Without question the best reason for the removal from the biology course of certain material of the nature outlined in the preceding ideas, is the fact that there is such splendid subject matter that needs to be used as replacement material for that which is removed. The subject material proposed in the remainder of this article is by no means entirely new to biology teachers. Some textbooks have introduced tastes of it with considerable success. Many teachers are already using portions of it in highly excellent manners. There is no claim that the suggestion of this material is anything new or startling; there is only the certainty that the substitution of the following suggestions would make our biology course eminently more worth-while:

1. Include practical information on the growing and care of grass, common flowers, and house plants. General biological principles and information regarding plant growth can be introduced with some reason when they are introduced in connection with things that already have a part in the experiences of the boys and girls. For example, a house plant can be used to show the tendency of plants to turn towards the light during their normal growth near a window. With this type of introduction the pupil understands immediately the functional value of that

particular bit of biological information. His study becomes study with a reason back of it, he is eager to have the information because he can use it, he does not just have to take it on faith, or because he is going to have a test question on it. If a biological principle cannot be introduced with common plants or animals furnishing the reason and background for the introduction of the principle, then perhaps that particular principle should not be introduced at all.

It is puzzling to know just why it has been thought desirable to spend a great deal of time on wild flowers, many of which are relatively uncommon and unknown to boys and girls, and not to mention roses or petunias in the entire biology course. From the standpoints of appreciation and general biological growth of plants, isn't it sensible to consider that the hybrid tea rose, a product of nature and man's biological knowledge, has much more to offer than a trillium? Naturally this does not mean that the trillium does not have something to offer also, but if it is a question of one type of flower or the other, isn't it more sensible to select the rose for biology, since the rose is the flower which has been selected ahead of all others for appreciation?

In our high school course, where else than in biology should a person get information about the growth and care of a beautiful lawn? Surely there is much biological information connected with this subject, and surely it is a type of information which most people need and use not only after they leave school but also while they are studying biology. There is real reason for functional biological information of this sort. It does not seem quite sensible that there should even be expert biology teachers who are so impractical that they know very nearly nothing about the proper method of planting a rose, or of seeding and growing a lawn. Perhaps this is one of the reasons why ordinary citizens so often look upon school teachers as being impractical and visionary. Perhaps our teaching of material of this sort is one correct way to gain respect for our work.

2. Center such subjects as instincts, reproduction, and heredity in animals about the keeping of common pets. In addition to the fact that scientific knowledge about the care and raising of dogs, for example, is a valuable kind of functional information because so many people enjoy dogs, there is also the fact that here, as in the growing of lawns and common flowers, there is wonderful opportunity for illustrating and developing important general biological principles, while at the same time ex-

cellent reasons for knowing these principles are presented.

We must not lose sight of the fact that the study of dogs and other common pets is likely to teach appreciation of animal life in a suitable manner. Appreciation of animals is possible largely through actual contact rather than by book contact, and quite evidently dogs, cats, canaries, or goldfish are not out of reach nearly as much as the many other less common animals which have excluded these common ones from our biology courses. As long as pupils know as little as they do about the biology of the well known animals, there is surely no need to wander far afield in search of unusual animals for emphasis.

3. Add material on conservation, especially soil conservation. In recent years biology courses have been adding excellent material on the conservation of wild flowers, forests, birds, fish, and other wild animals. This is splendid material for the high school biology course, although the subject still needs some enlargement. However, it is the subject of soil conservation that needs special emphasis. This subject belongs in biology because nearly every method of soil conservation depends upon the use of suitable methods of cropping, the growth of suitable plants, and perhaps even the development of new kinds of plants. It is not necessary to try to make soil conservation specialists out of young America, but only to teach general methods now known to be satisfactory in conserving our valuable soil. Even the dweller in the heart of a big city needs to understand the importance of the problem and to know why the government must take a major part in it.

In so many of our biology classrooms we have kept right on teaching our traditional biology while, almost outside the windows, farms blow away and hideous gullies form on hillsides that only a short time ago were covered with trees and grass. Muddy water rushes down the channels of small streams after every hard rain only to slacken and dry in a few short weeks after the seasonal rains are over. Many once prosperous farms have been abandoned completely. Much of the topsoil on other farms has been so badly eroded or depleted from overcropping that farmers find it difficult to grow anything. In badly eroded regions grass is thin and scattered, weeds have the upper hand, and any trees left are definitely second rate. Even the animal life in such sections has changed materially.

Although federal and state governments have begun to take a hand in soil conservation the problem is primarily one of

education, and the place for this type of education is a biology course suitable for every pupil in every high school.

4. Add material on plant and animal improvement through hybridization and selection. These important subjects are already valuable parts of many biology courses but they are worthy of greater expansion. Biology needs to emphasize the work of flower growers in developing the wonderful new varieties of flowers constantly being introduced and the work of agricultural experiment stations and universities in the improvement of varieties of wheat, corn, sheep, cattle, and many other similar food and clothing crops. Much more of this type of information belongs in the biology course.

5. More information is needed on vocations connected with biology. Here is another highly valuable field that the usual biology course has left practically untouched. Only occasionally has a live teacher stepped out with emphasis on the vocational type of information. This is a kind of information which is always attractive to pupils and which is so useful to them in helping them decide their work in life. The connection of biology with various vocations needs more than a brief mention of the fact that such a connection exists. Instead the course needs to give an idea of what each connected vocation is like, and to show just how biology is definitely related to the preparation for such work as entomology, commercial flower growing, greenhouse operation, animal breeding, bee raising, fish raising, fur growing, forestry, nursing, medicine, soil conservation, and many others.

These changes in the biology course would make the work somewhat less difficult and much more intersting and valuable to nearly all pupils. The suggested course would by no means be desirable only for low ability pupils although it would fit their needs and abilities excellently. Instead, such a course would be aimed towards the average pupil rather than the exceptional one, the average pupil being one of the 85% or so who never become scientists, who do not go to college, but who become ordinary common citizens taking care of lawns, growing flowers, raising pets and enjoying them, living more healthful lives, understanding and appreciating plant and animal life, and taking part in our national policy of conservation with understanding and intelligence.

Probably no other course now in our high school has a more wonderful opportunity to be of service to the pupil than does

biology. Let us build a biology course which every high school pupil should take and will want to take. Let us build a biology course which will live up to the wonderful opportunity it has.

THE WEATHER AS RELATED TO DEGREE DAYS

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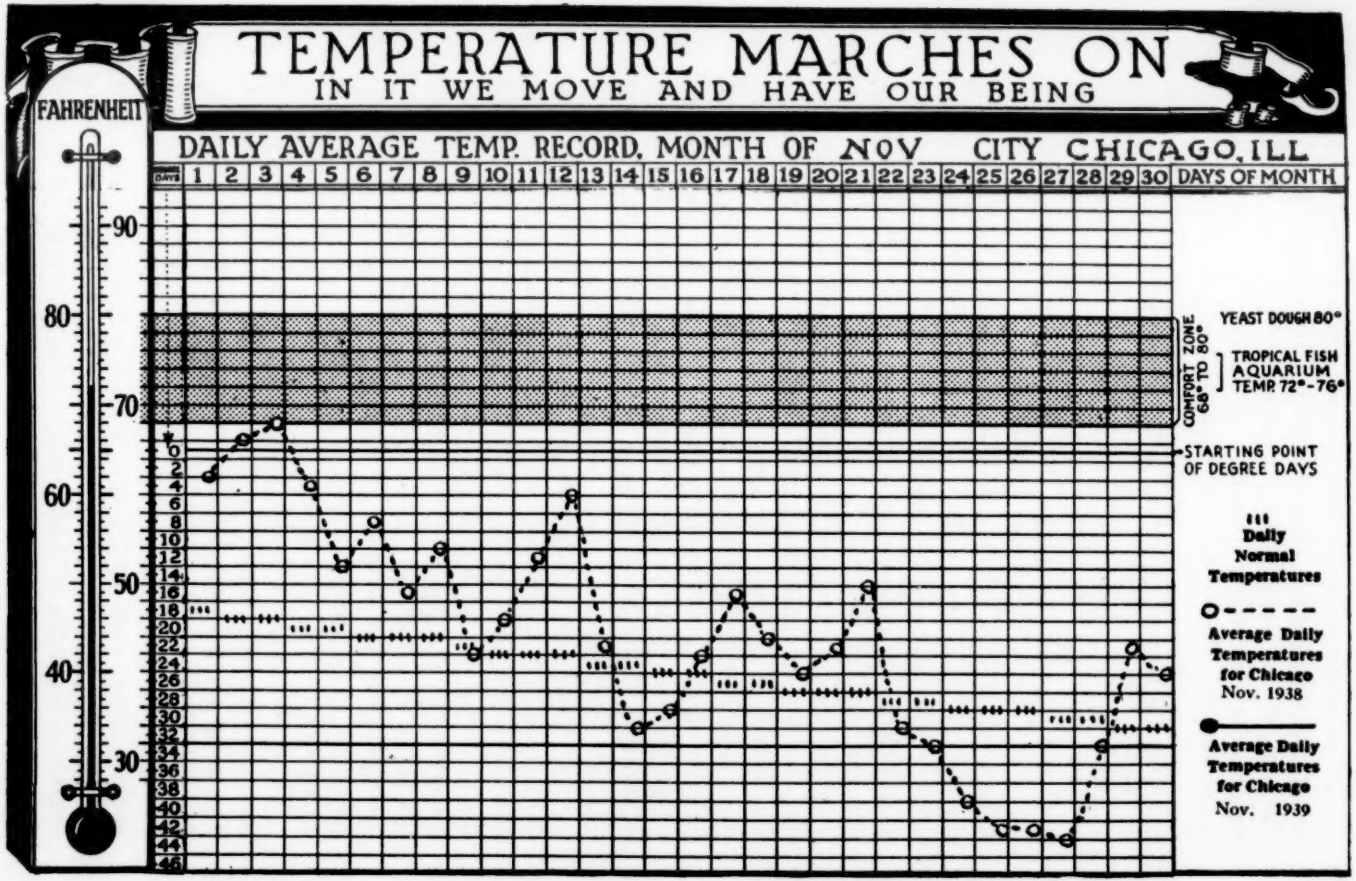
We often hear the remark: "Everybody talks about the weather, but nobody does anything about it." A more serious consideration of the subject may lead to some interesting speculations. There is too much taken for granted that the weather is beyond our control. Perhaps it is because our early ancestors feared the gods of the elements, and pleaded their mercy, that we still look upon the weather as some mysterious aggregation of forces beyond the sphere of human interception.

Science may some day tackle this subject and pull it down to the realm of possible regulation. In the meantime, there have been some remarkable strides made in what is generally known as air conditioning, which simply means indoor weather control. While much has already been accomplished in this direction, it is still confined to certain limited spots, when it ought to be universally applied. How soon air conditioning will be the rule rather than the exception, will depend largely upon the awakening of teachers generally, regarding this subject and all that it implies. If teachers were more air conditioning conscious, they would not be satisfied with merely theorizing upon the subject, but would demand its practical application in the school room. Think what it would mean if every school house, college and university were scientifically air conditioned. It would serve a twofold purpose. On the one hand, it creates a physical condition under which greater intellectual progress can be promoted, and on the other hand by example, the students would become accustomed and educated to the benefits of air conditioning and therefore would demand it in the home and workshop after leaving school. That would foster the objectives of education—make for a healthier, happier and wiser people.

One phase of air conditioning is concerned with what is known as "Degree Days."


TEMPERATURE MARCHES ON
IN IT WE MOVE AND HAVE OUR BEING
FAHRENHEIT
DAILY AVERAGE TEMP. RECORD, MONTH OF NOV CITY CHICAGO, ILL.
DAYS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 DAYS OF MONTH
90
80
70
60
50
40
30
COMFORT ZONE 68° TO 80°
YEAST DOUGH 80°
TROPICAL FISH AQUARIUM TEMP. 72°-76°
STARTING POINT OF DEGREE DAYS
Daily Normal Temperatures
Average Daily Temperatures for Chicago Nov. 1938
Average Daily Temperatures for Chicago Nov. 1939

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Due to the fact that the greater area of the civilized world has to contend with more or less cold weather for the larger part of the year, it has been found expedient to have some workable formula for determining heating requirements under varying conditions. This formula comprises the "Degree Day" tabulation system. The method of using degree days is simple. It is based on the assumption that 70°F. is the most generally accepted degree for body temperature comfort during that part of the day in which we are actively engaged in the affairs of life. It is also generally conceded that during the retiring period of the night, a slightly lower temperature is desired. 60°F. has been designated as the ideal temperature while at sleep. Taking the mean of these two points, we get 65°. This is taken as the basis or starting point for compiling the zero degree day on the yardstick of the degree day calculation. From this point they number from one down.

In recording the temperatures for the 24 hours of a day, the high and low extremes are noted. The mean of these extremes is also noted. If the mean or average for the day is above 65°, there would be no degree days, but if the mean is found below 65°, it would indicate as many degree days as the difference between 65° and whatever the lower mean happens to be. For an illustration, if that lower mean is 55°, there would be 10 degree days for that day.

Convenient charts or graphs are available for recording the daily mean temperature with the corresponding number of degree days. See illustration. Note that on the right side of the thermometer is a scale from zero down to 46. This scale makes it convenient to determine the degree days of any day by noting the curve of the mean on any given horizontal plane with its corresponding numbers on the degree day scale of the chart. Assuming again that the mean is 55° you will note the curve is on a plane with 10 on the degree day scale.

These charts are valuable teaching devices for every school room and students should be shown how these records are kept. The mean temperature information is usually published in the daily papers and is also accessible from the local weather bureau. The curves on the illustrated chart shows the mean temperature in the Chicago area for November 1938, compared to the Daily Normal Temperature given by U. S. Weather Bureau. These charts are available in blank form, so that they may be adapted for keeping degree day records in any locality.

THE CONSUMER PICKS HIS "ANTI-FREEZE"

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What brand of anti-freeze protection do you use in your radiator? Why? What was the basis of your choice? If you are like so many of us you will buy the kind that happens to be sold at the gasoline station where you normally take care of your auto requirements. Or, perhaps you might buy the brand whose advertising has struck your fancy. Even we, as teachers, too often do not correlate our teaching of the "scientific method" with our daily needs in life. Chemistry is a useful tool, an aid to intelligent living as a consumer. A real weakness in our teaching lies in our failing to sufficiently bring this out. Chemistry *is* something we can *really* use in our daily life, and our efforts must lie along the lines of truly "vitalizing" it to ourselves and our students. Too often we emphasize *past* contributions of Chemistry to Industry, Agriculture, Health, etc. without carrying along the thought that its content offers substance of real worth to us *today* and everyday.

Our laboratory course in high school Chemistry contains many experiments whose objectives are obscure and remote from practical significance to the pupils. They present a new technique, or bring out the properties of some chemical without much emphasis on how these facts can be useful to the students. Result? A half learned fact, retained by rote memory.

To illustrate how teachers can make their laboratory work more meaningful, we are outlining an experiment based on the geniune interest developed from a brief discussion of the questions presented at the start of this article. In an attempt to objectively and scientifically determine "which anti-freeze is most desirable in our radiators" the experiment here outlined can logically follow the discussion.

Experiment of Selection of an Anti-Freeze

Object: TO DETERMINE WHICH ANTI-FREEZE TO USE IN YOUR RADIATOR.

Apparatus and Procedure:

A flask containing a 100 cc. sample of pure anti-freeze solution is placed into a water bath kept at the boiling point (100 deg. C.). The flask is coupled to a Liebig condenser. The time to distill 50 cc. of alcohol is measured as well as the boiling point of the alcohol. Specific gravity is taken on the original sample with a hydrometer, and the figures recorded. A calorim-

eter, filled with snow and salt, is used to check the slush point of the sample.

MATERIALS:

1. Three nationally advertised brands of anti-freeze solutions.
2. One 100 cc. sample of ordinary denatured alcohol (available in every laboratory).
3. Hydrometer.
4. Thermometers.
5. Calorimeter (can be made from two tin cans, inserted one in the other, and separated by cotton batting, or rags as an insulator.

TEST FOR FOLLOWING POINTS	METHOD OF TESTING
1. Boiling point of pure anti-freeze.	1. Taken during distillation of sample by thermometer inserted in flask containing anti-freeze solution.
2. Specific gravity of pure anti-freeze solution.	2. Hydrometer.
3. Which anti-freeze will boil off least rapidly under adverse driving conditions?	3. 100 cc. samples of pure anti-freeze solutions can be placed in water bath, and time to distill 50 cc. measured. Alternate method: Mix the manufacturer's recommended proportions of anti-freeze and water to give protection at 0 deg. F., and then measure time to distill off definite volume of anti-freeze solution.
4. Is claim of certain gas attendants true that "their anti-freeze will not lose its protective power even under adverse conditions"?	4. Check freezing points of recommended mixtures just as mixed, and again, after distillation of a large fraction of the anti-freeze. For example, using 100 cc. sample, distill off 30 cc. and test freezing point of residue in flask.
5. Is a layer of ordinary lubricating oil in the radiator effective as an "evaporation retarder"?	5. Make up two samples of recommended mixtures of anti-freeze and water, (good for about 0 deg. F.). Add a $\frac{1}{4}$" layer of oil to one, and measure time required to distill off equal volumes of the two samples.
6. How do the "anti-freezes" compare with ordinary denatured alcohols?	6. Distill 100 cc. sample of ordinary denatured alcohol in same manner as previously done with commercial solutions.
7. What is the probable composition of the anti-freezes tested?	7. Compare the boiling points and specific gravities of the pure samples with the published data for pure methyl, ethyl, and propyl alcohols.

TABULATION OF RESULTS OF TESTS

Sample	Retail price ¢/qt.	B.P.* pure anti-freeze	Specific gravity pure anti-freeze	Time to distill 50 cc. pure anti-freeze (minutes)	F.P. of mixture recommended for 0°F	F.P. same mixture after distilling off 33% (0°F)	Time to distill 10 cc. of 50/50 mixture anti-freeze and water. (No oil layer) (minutes)	Time to distill 10 cc. of 50/50 mixture of anti-freeze and water. (With ¼" oil layer on surface) (minutes)
Nationally Advertized Brand "A"	30	80.5	0.81	19	Not frozen	24	12	34
"B"	15	66 to 74	0.88	12	Not frozen	23	12	34
"C"	25	69	0.79	12½	Not frozen	21	12½	20
Ordinary Denatured Alcohol "D"	15	79	0.81	24	Not frozen	18	12½	19

* B.P. taken after first few cc.'s had distilled over, and boiling point has become "constant."

NOTE: A check of mixtures drawn out of radiators of several cars for freezing point may be made as part of the experiment to see how "actual protection" compares with "protection they thought they had."

CONCLUSIONS:

1. Since the boiling points and specific gravities of samples were so close to the values accepted for methyl and ethyl alcohols, these anti-freeze solutions were largely mixtures of these two alcohols, or were practically pure methanol. Samples A and D appear to be largely grain alcohol, while sample C is apparently largely methanol.
2. That the price paid for anti-freeze solutions of the alcohol type is no criterion of their ability to protect against radiator freeze-ups.
3. That ordinary denatured alcohol was at least as effective in preventing freeze-ups as any of the samples of nationally advertised brands tested.
4. That a ¼" layer of ordinary lubricating oil in the radiator seems to act as an "evaporation retarder." (This probably is a similar action as was experienced on domestic household refrigerators employing sulphur dioxide as a refrigerant, where the lubricating oil of the compressor was trapped in the evaporator of the refrigerator, the oil acting as a blanket which prevented evaporation of the refrigerant. This condition is referred to as "oil-binding.")
5. That manufacturer's recommended mixtures actually provide adequate protection against freezing temperatures as claimed, at the start.
6. That all anti-freezes tested lost most of their protective power upon being exposed to elevated radiator temperatures for a period of time.

Out of this experiment can rise a discussion of the power of advertising in influencing a purchase. This will logically lead to the need for a scientific, objective approach in making proper

selection of the materials we use as consumers, and how prejudice should give way to truth. This concrete, definite approach to "fractional distillation" stimulates genuine respect for the scientific method.

The principles of fractional distillation, the use of freezing points and boiling points in industry as a guide of purity of material, and the many practical uses of these processes in the products they will buy and use as consumers will unfold naturally out of a truly personal problem of the individual. Such information will not soon be forgotten, as it is based on a "real" problem and interest. Further, it can at once be of real value to both those preparing for college careers, as well as those taking Chemistry for informative purposes. Both groups have need for experiments which will enable them to live more intelligently in an increasingly scientific world.

IF TWO EXTERNAL BISECTORS ARE EQUAL IS THE TRIANGLE ISOSCELES?

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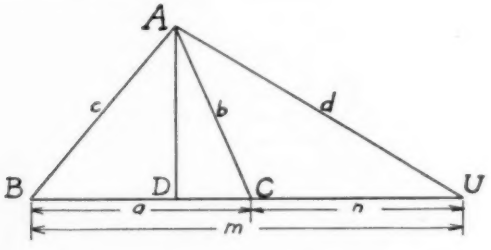
The following extension of Stewart's Theorem* will be of assistance in answering the proposed question.

Theorem (I) The square of the distance of a point on the base produced of a triangle from the opposite vertex multiplied by the base is equal to the difference of the squares of the other two sides, each multiplied by that segment of the base line which has no end in common with the side, plus the product of these two segments multiplied by the base.



Let $d = AU$, the distance from point U on BC produced to the

* See *College Geometry* by N. A. Court, p. 109.

opposite vertex A. Denote the segments of the base produced to U by $m \equiv BU$ and $n \equiv CU$.

Then we have in triangles ACU and ABU that

$$b^2 = d^2 + n^2 - 2n\overline{DU}, \tag{1}$$

$$c^2 = d^2 + m^2 - 2m\overline{DU}. \tag{2}$$

Multiplying equation (1) by m, equation (2) by $(-n)$ and adding gives

$$mb^2 - nc^2 = (m-n)d^2 + mn(n-m). \tag{3}$$

Rearranging and using the fact that

$$m - n = a \tag{4}$$

gives

$$ad^2 = mb^2 - nc^2 + amn. \tag{5}$$

This is the algebraic statement of Theorem I.

If AU is the external bisector of angle A, then

$$\frac{m}{n} = \frac{c}{b}. \tag{6}$$

Solving equation (4) and (6) for m and n gives

$$m = \frac{ac}{c-b}, \qquad n = \frac{ab}{c-b}. \tag{7}$$

Substituting these values in equation (5) gives the square of the length of the external bisector at A in terms of the sides of the triangle

$$\overline{AU}^2 = \frac{bc(a+b-c)(a-b+c)}{(c-b)^2}. \tag{8}$$

Denote by V and W the points in which the external bisectors drawn from B and C respectively meet the opposite sides produced. The expressions for the squares of their lengths may now be written down by cyclic permutation

$$\overline{BV}^2 = \frac{ac(a+b-c)(b+c-a)}{(c-a)^2}, \tag{9}$$

$$\overline{CW}^2=\frac{ab(a-b+c)(b+c-a)}{(b-a)^2}. \tag{10}$$

Question: If two external bisectors are equal is the triangle isosceles?

Forming the difference of the squares of the bisectors drawn from B and C gives

$$\overline{BV}^2-\overline{CW}^2 = \frac{a(b+c-a)}{(c-a)^2(b-a)^2}\left[c(a+b-c)(b-a)^2-b(a-b+c)(c-a)^2\right]. \tag{11}$$

This becomes

$$\overline{BV}^2-\overline{CW}^2 = \frac{a(b+c-a)(c-b)}{(c-a)^2(b-a)^2}\left[a^3-(b+c)a^2+3bca-bc(b+c)\right]. \tag{12}$$

Similar expressions for the other two possible differences may be written down by cyclic permutation.

Equation (12) contains the answer to the question proposed. Further it provides a beautiful illustration of necessary and sufficient conditions.

Theorem II. If a triangle is isosceles, then two of the external bisectors are equal.

To verify the truth of this theorem note that the right member of equation (12) contains the factor $c-b$ and hence vanishes if b equals c.

Theorem III. If a triangle has two of its external bisectors equal then it is either isosceles or one side is the real root of a cubic equation of the type illustrated by

$$a^3-(b+c)a^2+3bca-bc(b+c)=0.$$

If $BV=CW$ then the left member of equation (12) vanishes but the right member may vanish because $b=c$, the isosceles case, or it may vanish because side a is the real root of the equation

$$a^3-(b+c)a^2+3bca-bc(b+c)=0. \tag{13}$$

Equation (13) has one real and two imaginary roots.

The real root has the value

$$a=\frac{b+c}{3}+\sqrt[3]{\frac{(b+c)^3}{27}+\sqrt{R}}+\sqrt[3]{\frac{(b+c)^3}{27}-\sqrt{R}}, \tag{14}$$

where

$$R=\frac{bc[27b^2c^2-9bc(b+c)^2+(b+c)^4]}{27}.$$

Note that R is always positive.

To provide a numerical example let

(15) $$b=4, \qquad c=5.$$

Then approximately

(16) $$a=4.53-, \qquad BV=40.\pm, \qquad CW=40.\pm.$$

For those who prefer a more elegant relation than the cubic given but one less suited to computation, the following form of equation (13) is included

(17) $$\frac{(s-a)^2}{a^2}=\frac{(s-b)(s-c)}{bc}.$$

Hence if the external bisectors drawn from B and C are equal then $(s-a)/a$ is the geometric mean of the quantities $s-b/b$ and $s-c/c$. Equation (17) may readily be obtained from equation (13) as follows. Multiply equation (13) thru by $a+b+c$, combine terms, add and subtract a^2bc, factor, and introduce s.

MATHEMATICS MEETING AT COLUMBUS

The National Council of Teachers of Mathematics will hold its Sixth Annual December Conference jointly with the Mathematical Association of America and the American Association for the Advancement of Science on December 28 and 29, 1939, at Columbus, Ohio. The theme of the meetings is "Relational Thinking in Secondary School Mathematics Teaching." The general program is as follows:

1. Joint dinner meeting with the Mathematical Association of America, December 28, 6:30 P.M.
2. "Training Teachers for Relational Thinking," December 29, 9:30 A.M.
3. "Relational Thinking in Secondary Mathematics as Viewed by the College Teacher," December 29.
4. "Teaching Children to Do Relational Thinking," December 29, 2:00 P.M.
5. Joint Meeting with the Mathematical Association, December 29.

Any teacher interested in any part of the program is cordially invited to attend. There is no admission charge.

Details, including headquarters, places of meeting, speakers, reservations for the dinner, will appear in the December issue of *The Mathematics Teacher*. Suggestions and questions should be directed to A. E. Katra, Executive Secretary, N.C.T.M., 525 West 120th Street, New York, N. Y.

MATHEMATICAL PRINCIPLES IN THE JUNIOR HIGH SCHOOL*

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INTRODUCTION

While the term *junior high school* designates an educational organization constituting the grades 7, 8, and 9 as a separate unit, we shall employ the term *junior high school mathematics* to designate the mathematical topics commonly taught in these grades, no matter whether the three grades constitute an integral part of a 6-3-3 plan, or as separate parts of an 8-4 plan. Moreover, since there are many different types of courses taught in the three grades under consideration, from the various types of traditional compartmental courses in arithmetic for grades 7 and 8 and algebra for grade 9 to the many differently organized unified or general mathematics, we keep in mind the mathematical processes and concepts which are better suited for instruction at the levels represented by these three grades. The teaching of such mathematical processes and concepts has been justified by the teachers of mathematics on the following two bases:

1. The learning of such concepts and processes facilitates the learning of other subjects at the same or at a higher level.
2. The learning of such concepts and processes constitutes an integral part of the general education of the child.

Consequently, we are concerned here with a discussion of the mathematical processes and concepts which are usually taught (or ought to be taught) in grades 7, 8, 9, in order to understand more fully the part that the mathematical instruction in these grades plays (or ought to play) in the general scheme of education. Rather than approaching the problem (as is commonly done) by itemizing such separate mathematical processes and concepts and then proceeding to justify their presence in the curriculum, we shall endeavor to formulate in a general way what the educational functions of mathematics are, both specific and general.

* Presented before the Junior High Section of the Central Association of Science and Mathematics Teachers at the Annual Convention in Chicago, November 26, 1938.

I. The Unique Educational Functions of Mathematics

In any educational program the designation of certain mathematical courses as arithmetic, algebra, geometry, etc., is purely arbitrary. While there may be good reasons why such an arbitrary separation of mathematics into distinct courses may aid in the training of the specialist, there is no rime or reason why the mathematical education of the non-specialist should follow the same lines. No one will contend that the education of a child in grades 7, 8, and 9 ought to be along the lines of specialization, yet often the educational program is so formulated as to lead to this undesirable end.

While no attempt shall be made to define mathematics, we recognize the important fact that mathematics is a mode of thinking created by man to better understand the quantitative aspects of the world about him, to analyze his own life in terms of such quantitative relationships that affect it, and to present the findings of his own analysis in a precise and concise language or to understand the findings of others when presented in this language. Thought of as a method of thinking mathematics is an integral part of any educational system. It is in this sense that mathematics can play the important role in the life of the individual that it has played in the life of the race.

1. *Rationalization of the Number Concept.* The development of a number system has been one of the most outstanding contributions to the progress of civilization. It is the representation of quantities by numbers that replaced barter by a credit system, and credit forms the life stream of commerce and international trade.

In order that a number system be suited to the requirements of our civilization it must of necessity meet certain conditions which are imposed upon it. In the first place, the *base* of the number system must neither be too large nor too small. The base 10 of our decimal system requires ten names, whose combinations with a few additional ones, such as the hundred, thousand, million, and so on make it possible to represent conveniently any number whatsoever.

In the second place, the *symbols* used for the names of the numbers of a system must have the property of representing any number without the necessity of introducing new ones. The advantage of the decimal system over other ancient systems lies in this very fact.

In the third place, a number system must possess the idea of

place or *positional* value. In the decimal system the value of a digit depends upon the place or position it occupies with respect to other digits. Thus, the digit 5 has different meanings in the three numbers 529, 459, and 425. This principle is a distinguishing characteristic of our number system.

In the fourth place, a number system must contain a *zero*. Without a zero we could not distinguish between such numbers as 45, 405, 450, etc. While the idea seems simple to us, we should remember that the race had to struggle for many centuries to develop it into its present meaning.

It is true that the base of our decimal system was arbitrarily chosen, perhaps because man has 10 fingers. However, this system is simple, adequate, and complete. Our number system was not sent down to us from Heaven, rather it represents the struggles of the race over countless ages. An attitude of appreciation of the number system is a proper attitude of appreciation of the contributions of many peoples and ages to develop it into its final perfect form. If this appreciation is not developed in mathematics classes in the junior high school, for a large majority of the children it will never be developed.

2. *Mastery of the Fundamental Operations*. Associated with the concept of number and intricately woven into it are the attendant processes or operations. Starting with the simple process of counting, man first developed the idea of the integral or whole numbers, performing his combinations of numbers (or quantities) by recounting the combined groups, until finally he invented the operation of addition. Addition then is followed by multiplication as an abbreviated kind of addition, and in turn the inverse operations of subtraction and division are introduced and developed.

However, the inverse operation always introduces unforeseen difficulties. Subtraction is not always possible unless a new concept of the number is developed, namely, the directed number. Similarly, division introduces the new concept of rational number. The enlargement and refinement of multiplication into the process of involution or raising to powers was but a natural consequence. However, again the inverse process of evolution, or extraction of roots introduces a new number, the irrational, and the imaginary.

Thus from time immemorial until the present age mankind has struggled to enlarge the boundaries of the number to meet all the ever increasing needs. The development of number and

the number-operations has gone hand in hand with the advance and progress of civilization.

3. *Development of Spatial Concepts.* Along with the idea of number the primitive man developed gradually a recognition of the geometric forms abounding in nature. The first geometry was artistic and religious. Then followed constructive geometry which utilized geometric forms in temples, dwellings, utensils, etc. Finally geometric ideas culminated in the logical or demonstrative geometry of the ancient Greeks.

The world in which we live is physical. Familiarity with the physical universe necessitates a development of the elementary spatial concepts which are inherent in the child. Certainly, by the time he is through his elementary school training, the child should have an adequate background in intuitive geometrical concepts.

4. *Variables and Relationships.* We may lay down the dictum that "the only permanence is change." One might search far and wide in a fruitless effort to find unchanging and constant quantities. Everywhere the reign of change is absolute and supreme. Thus, along with the idea of number we must consider the notion of variable as of utmost significance in the orderly arrangement of man's thoughts about the quantitative world. Quantity is represented by number, and variable quantities, by variable numbers, or *variables.*

Important as is the notion of change or variation, yet of far greater importance is the knowledge of the manner in which the variation takes form. For variation of one quantity is either the result or cause of a corresponding variation of another quantity. Thus, variation is attended by a relationship between variables.

5. *Intelligent Interpretation of Tables.* The related changes of quantities are conveniently represented by an arrangement of the corresponding values of the quantities in a table. Such an arrangement is often called *tabular representation.* Being a detailed numerical description of a quantitative relationship a table has an interesting and enlightening story to tell about the relationship which it describes. The story may be read by him who understands the language of mathematics in terms of the *ranges, intervals, differences, rates,* and so on. Taken together these properties of the table present an adequate picture of the relationship.

6. *Working Knowledge of Graphs.* While the tabular arrange-

ment is certainly a more advanced step in the study of statistical data than a listing at random, yet for many purposes the graphic exhibition of the data is more economical and more effective. The idea is extremely simple and quite interesting to the child. The argument in favor of its early introduction in the course, such as the bar and circle graphs in grade 7, and its continued development to more advanced types in later grades, such as the line graph in grade 8, and the curved graph in grade 9, is the wide applications of the graphic method in all types of statistical data, commercial, industrial, and scientific.

7. *Knowledge of Symbolic Representation.* Functional thinking is readily admitted by mathematicians to be the most important educational objective of the elementary courses in mathematics, and by non-mathematicians as well, when they have a clear understanding of the concept. Functional thinking is thinking in terms of and concerning quantitative relationships. The three phases in presenting a relationship are the *tabular*, the *graphic*, and the *algebraic* methods of representation, the process culminating in the last. That is, while the tabular and the graphic methods throw much light upon the nature of the relationship, it is the algebraic form of expression of the relationship which is perhaps the most nearly adequate.

Symbolic representation by means of a formula, or equation, enables the thinker to express his separate observations as an all embracing general relationship, or law. In this form he is able to think in terms of any element of the class rather than specific elements. The properties of the "any" element, the representative element, then become the properties of the class. Thus, any law which governs this representative element must of consequence govern the class which the element represents. Two or more related representative elements thus exhibit the relationship between their respective classes. The relationship is then stated in terms of the representative elements, and is applicable to all the elements of the related classes.

Man is ever endeavoring to understand and appreciate related changes. The relationships in any particular domain constitute a science. The applications of the relationships of that particular science alter the mode or manner of our lives. To live in a civilization which is governed and controlled by the applications of the various sciences imposes upon the individual an obligation to understand in a measure the language of the sciences. Their common language is algebra—the symbolic language.

8. *Knowledge of the Process of Measurement.* Mathematics has been appropriately called "the language of size," while ordinary language, "the language of sort." The size may be that of a single quantity, or of a class of quantities. The determination of the size of a quantity or of a class of quantities, is *measurement.* The specific quantity may be a distance between two points on the earth or between two points in the inter-stellar space, the surface of a radiator or of a planet, the mass of a bacterium or of a giant star, the population of a state or the number of molecules in a drop of water, the number of coins in one's purse or the enormous national debt, and so on *ad infinitum.* Everywhere we are surrounded with quantities whose sizes challenge us either of necessity or of curiosity.

The process of counting, directly as in the case of the number of people in a room, or indirectly as in the case of the number of molecules in a drop of water, is but a form of measurement, the unit of measure being a single element, man, or molecule.

In general, measurement is a process of *comparison.* The comparison is between the quantity to be measured and a like quantity arbitrarily determined and accepted as a standard. The latter is called a *unit* of measure. When the comparison is made between two like quantities, a number is obtained which differs from the abstract number of arithmetic in one important respect. The number obtained by measurement is not exact. It may be represented to any degree of accuracy or precision consistent with the means and purpose of measurement. All measurements are approximate, and numbers obtained by measurement or representing measured quantities are correct to a certain number of significant figures. The degree of accuracy of such an approximate number is represented by the actual or probable error made in measurement.

To appreciate the significance of measurement in our lives we need only mention one problem of measurement with which mankind has struggled for countless ages, namely, the measurement of time. Furthermore, without arbitrarily accepted standard units of measure ordered society would revert back to chaos.

9. *Properties of the Geometric Figure.* The study of quantitative relationships is and should be one of the primary objectives of any mathematics course. The relationships between common geometric figures are of such utmost significance to us that their understanding should constitute one of the major educational

objectives of the junior high school, and their teaching should be direct and not incidental.

Of the many relationships between the simple geometric figures about us, the relationships of *congruence*, *similarity* and *symmetry* are best adapted to the inductive method of approach. These three important relationships serve as a means of putting to practical uses the facts and principles of geometry.

Congruence implies that two or more figures or objects have the same shape and the same size. The meaning of congruence is demonstrated by a host of different types of standardized objects such as coins, dishes, comic strips, automobile parts, and so on *ad infinitum*. Mass production utilizes this simple geometric relationship.

Similarity, on the other hand, implies that two figures or objects have the same shape, but not necessarily the same size. Similar objects resemble one another. Since shape is an important attribute of organisms, similarity plays an equally important role in the identification and classification of species.

Symmetry, a topic entirely neglected in the junior high school classes, has to do with certain characteristics of the shape of a figure or object which endows it with a pleasing appearance. The shape of a geometric figure, an object, or an organism is the sum total of the physical aspects which it presents to the eye. One object presents a more pleasing appearance than another. We call the former more beautiful. This pleasing appearance is a combination of such properties as color, texture, shape, and others. Of them, shape is the most important, because without a pleasing shape the other properties lose their effectiveness.

The beauty of shape can be appreciated through observation. We say a thing is beautiful because it pleases the eye, and that too without often being able to analyze the reasons for our appreciation. However, in order to understand the beauty of form, we must resort to measurements. We determine the specific relationships between the principal parts of a figure which endow it with its peculiar pleasing appearance.

The appreciation of the beauty of form is an inherent ability of man and it should be developed as early as possible in the school. Its development might aid in the eradication of much unnecessary ugliness in the world.

10. *Development of Efficient Reasoning*. While educators and teachers have had much to say about the desirability of develop-

ing in the child the ability to reason, they have manifested but little directed and concerted effort through specific courses toward this desirable goal. Many assume that the teacher in every course is training the child to think logically. Unfortunately, it often happens that what is considered the task of all is performed by none. No, if this desirable attribute is ever attained, it will be because of purposeful teaching in suitable courses.

Reasoning is manifested in our desire to discover the truth, to discriminate between the worth while and the trivial. Reasoning classifies the various aspects of truth in terms of such statements or assertions which we accept as true without demanding a proof, and others whose soundness can be established by proof. Our attitude toward life and its laws, toward society and its regulations, toward one another and the rules of proper conduct may be one of passive acceptance or critical analysis. Happiness, be it personal or social, depends in a large measure upon adherence to sound principles and the elimination of harmful elements.

Logical reasoning is reasoning in an orderly manner. It follows a definite proceedure. The person who can reason logically may at times make mistakes and arrive at wrong conclusions; but the person who cannot reason cannot even form a judgment. He lives blindly, trusting to luck, and is a prey to more shrewd individuals.

II. General Educational Functions of Mathematics

The concepts and processes of mathematics of the junior high school with their unique educational objectives have been considered thus far. There are other educational objectives of these mathematical concepts and processes which though not peculiar to mathematics, nevertheless, to the attainment of which mathematics contributes in a definite manner. We may term such objectives as *general educational functions* of mathematics.

The general educational functions of mathematics, where realized, take the form of desirable attitudes which actually function in the life of the individual. We consider below ten such attitudes which supplement the ten-point program of the unique educational functions of mathematics.

1. *Intelligent Attitude Toward Problems.* In considering this educational outcome we may state at the outset that it is im-

material whether it is attained in a mathematics course or in some other course. The important thing to keep in mind is that the average man should develop an intelilgent attitude toward problems, and in so far as possible a technique for handling them. Every person encounters during his lifetime innumerable problems upon whose solution depends in a large measure his happiness and his mode of living.

It is quite true that the average person does not have the ability to solve many of his life problems. In most cases he engages the services of others who have developed a problem-solving technique in special fields. Thus, he pays a physician to solve his health problems, an attorney to solve his legal problems, and a mechanic to solve the problems arising from the operations of an automobile.

It does not require keen analysis to demonstrate the fact that life is but an aggregation of complex problems: Problems that must either be solved or remain unsolved, and if solved, they are either solved by the individual himself or by a specialist.

In mathematics a problem is stated in a language incapable of misinterpretation, the factors are readily identified and completely known, the precise method of solution is determined and used, and it is possible to check the solution to be certain that it is correct. For this reason the subject of mathematics can offer specific aid in developing an intelligent attitude toward problems, and in acquiring a problem-solving technique.

2. *Intelligent Attitude Toward Order.* The physical universe of a scientist is an ordered universe, each component part ordered in its relationships to the other component parts, together presenting a complete meaningful whole. Similarly, in the social order, the various social units, the individual, the family, the community, the municipality, and the state constitute an ordered and meaningful whole. The attitude of the individual toward the society or toward the more extensive universe depends upon whether or not the constituents of the society and the universe form an ordered whole in his mind. Much of the maladjustment and the attendant misery and suffering of the individual would be eliminated or at least lessened if his attitude in relationship to the social order was that of intelligence and understanding.

The thought processes in mathematics of necessity are ordered processes, whether such orders are serial or logical. Even in its

operations mathematical thinking is ordered thinking, be it an analysis of a complex problem or the application of a known formula to specific cases. A systematic procedure in a series of ordered steps in his mathematical thinking should and can develop in the individual an appreciation for order and an intelligent attitude toward any order of which he is a part.

3. *Intelligent Attitude Toward Laws.* An established order, be it physical or social, must be a simple order in order to be effective, accounting for all of the integral parts it contains in their relationships to one another and to the entire order. These relationships are the laws governing the order. In the physical universe they are the so-called natural laws explaining the various phenomena manifested in the order. Thus, the solar system, that is, man's conception of the system, is a simple order with laws that explain the movements of the planets and other members of the system, as well as other phenomena which would be unintelligible without an understanding of the laws. Similarly, the social order is kept together and maintained by certain laws that govern the relationships of the members of the society. Many of these social laws are but man made regulations. Whether any particular social regulation is good or bad is beside the question. As long as that regulation contributes toward the well being of the social order it applies in its regulatory powers to all the individual members constituting the social order. The laws of the order cannot be violated without destroying the order.

Here is where mathematics courses can be of utmost help in the development of future citizens, intelligent citizens, with a consciousness of their obligations to the laws of the social order as long as those laws remain the laws of that particular order and as long as the individual remains a member thereof. This is and should be just as true as the equivalent truth that you cannot defy the natural laws without suffering the consequences.

4. *Intelligent Attitude Toward Relationships.* By understanding the relationships of nature, man has been able to harness natural forces and to make them serve him. Nature in many instances has become the handmaiden of science because the scientist has taken the time through much labor and energy to understand the relationships between natural forces. A scientist is primarily concerned not with the nature of things but with the relationships between things. The understood relationships become the applications of science.

As pointed out above, if functional thinking is developed in mathematics, the individual becomes conscious of ordered dependencies and relationships. These ordered dependencies operate in his own life in his relations to the physical universe of which he is a part and in his relationships to the other members of the family, the community, and the society. It will be recalled that in a functional relationship involving say two variables, the variables have the freedom of assuming any values within their respective range of admissible values. However, one condition must be satisfied, and that is, the correspondence between the related values of the variables must not be destroyed. What a lesson of rich and meaningful consequences! Let the child in his mathematics courses, as well as his other courses, learn this lesson of the inviolability of the relationship. Once an intelligent attitude is developed within the child toward his relationships to others, we may reasonably expect that it will operate in his life to his own advantage and happiness.

5. *A Scientific Attitude.* The development of a scientific attitude is, or should be, a desirable learning product of our schools. By scientific attitude we do not mean specialization in any particular science. But we do mean the development of an intelligent attitude toward scientific laws and phenomena, and toward the inventions and discoveries which the application of the scientific laws has made possible.

The various sciences, physics, chemistry, astronomy, medicine, and others, have modified the old civilization and have moulded it into a unified system. What our attitude should be toward this civilization depends upon the type of education we receive when young. Our attitude could be that of indifference, similar to that of a butterfly in a flower garden, enjoying the nectar as it flits from flower to flower, asking no questions and caring nothing as to the why and the wherefore of its existence. The butterfly is not concerned with the permanence of the garden and its maintenance in order that other butterflies in the generations to come may also enjoy the garden. Such an attitude takes civilization for granted as we do the air we breathe. This passive acceptance of civilization, nevertheless, makes us its trustees to maintain it in good faith and hand it down to the coming generations in as good a state of preservation as when handed down to us, even if we do nothing toward its improvement.

The person who is fortunate enough to be endowed with a

scientific attitude and who desires to become a part owner of that vast amount of knowledge that mankind has accumulated throughout the ages must be able to read and understand the language of science. That language is mathematics.

6. *Intelligent Attitude Toward Transformations.* Consciousness of changes in life and the world reflects in a desire, on the one hand, to understand the logic of the changes, and on the other hand, to conform to the consequences of such changes. An ordered universe, be it physical or social, must of necessity undergo ordered changes or *transformations.* Transformations in society are just as inevitable as in the life of an individual. The form at any given period of time must conform to the desired ends, that is, it must undergo a transformation. Change for the sake of change is wasted energy. Change must be a transformation with a definite purpose in view. An understanding of transformations and an intelligent attitude toward them are the characteristics of an intelligent personality.

But how is this attitude to be developed in mathematics courses of the junior high school? Reflect a moment! An equation is changed from one form to another, that is, transformed according to a law. Why? Certainly not for the joy of knowing that we can so transform it. No! We transform it with a purpose in mind. It may be that we desire to solve the equation, or to put it in a required form. Our changes of mathematical forms in elementary courses are ordered changes, or transformations.

7. *Intelligent Attitude Toward Invariants.* Ordered changes are necessary for the growth of the individual. So are transformations equally necessary for a healthy growth of society. However, throughout the changes which the individual undergoes he must keep his identity, his personality. So must society preserve its integrity throughout the transformations it undergoes. The qualities of the individual or society which remain unaltered are the *invariants* under such transformations.

Now the race has undergone many transformations through the ages. However, there are certain invariants of life that we identify and recognize at any stage of man's development. These invariants of life are the worth-while things for which men have often willingly died. They may take such intangible forms as patriotism, decency, loyalty, etc., but whatever their particular manifestations may be, they form the fabric that makes continuity of social order possible.

The study of invariants, though not usually emphasized in

the courses of elementary mathematics, can be so emphasized by the teacher who is conscious of their importance and significance. They may be illustrated by such a simple example as the solution of equations. When an equation is transformed by dividing its terms by a certain number, the form of the equation is changed, but under that transformation there remain unaltered such properties as the degree of the equation and its roots.

8. *Intelligent Attitude Toward the Principle of Representation.* The class of individuals which we call a society, as we have seen, has certain group properties in common. The working out of the laws which govern these common properties necessitates a division of the civic duties and obligations. In order that the citizen may have a voice in the maintenance of the social laws he resorts to the principle of representation. The representative form of government imposes certain obligations upon an individual if proper representation is to be carried out. The representative government is as effective and efficient as the attitude of the individual citizen.

The principle of representation is evident in elementary mathematics whenever we represent a range of admissible numerical values by means of a variable. This reciprocal correspondence imposes certain conditions upon the variable which represents the class of values. The understanding of this principle and its application in the affairs of life is not too much to ask of our schools.

9. *Intelligent Attitude Toward Special Cases.* The generality of a law is substantiated by its applications to special or specific cases. Contrary to the general belief, an exception does not establish the rule. A single special case may destroy a beautiful hypothesis. We should keep in mind that the many special cases are the elements of the class having the property described by the law. When an element of the class does not possess that property it is wrongly classified and is foreign to that class. Either the law must be restated to cover all the special cases, or the cases must be modified to conform to the law.

How many respectable citizens have the attitude that a certain law is quite desirable, but it does not apply to them individually, unintentionally implying that they are unique special cases outside the range of the law! While such an attitude is pathetic in a few special cases, it is dangerous if there are too many of them. Socially speaking, either the laws must be obeyed by all the members of the social group, or else the laws should be modified.

Nowhere is this principle so easily and so forcefully demonstrated as in mathematics. The specific relationships between the special cases (represented by the specific values of perimeters) are but manifestations of the general law (represented by the functional equation).

10. *Intelligent Attitude Toward Generalizations.* A great deal of the mischief caused by the so-called social, psychological, pathological, and other "laws," is due to the fact that the "empirical law" is often a result of but a few isolated observations. We are ever ready to generalize our experiences and observations. We readily subscribe to claims of the interested parties in behalf of "cure-alls." And if these claims are substantiated by "authorities," then that clinches the argument for us. Who are we to question or critize expert opinion?

The relationship between special related cases and a generalization covering such cases should be taught and learned in our schools and not through expensive and often sad experiences of later life. A proper attitude should be developed toward this principle, an attitude which inquires into the validity of the presented generalizations, an attitude which accepts a given generalization for its genuine worth and not for the claims advanced in its behalf. Such an attitude is the very essence of an intelligent consumer outlook toward the highly and widely advertised products, of the intelligent citizen who is asked to subscribe to all kinds of social reforms advocated by interested groups and supported by "experts."

Mathematics courses of the junior high school offer a splendid opportunity for the development of such a desirable attitude. Generalizations in elementary mathematics are readily arrived at through the inductive method. They are equally readily substantiated in terms of definite specific cases. The responsibility rests with the teachers of mathematics, and with them alone.

DISCOVER MEDICINAL VALUE OF FRESH PINEAPPLE JUICE

Fresh pineapple juice has a specific medicinal value, two University of Wisconsin scientists, Julius Berger and Conrado F. Asenjo, have discovered. It contains an enzyme, bromelin, which like other enzymes, such as ficin from the sap of the fig tree, is not poisonous to man but can destroy certain types of parasitic, disease-causing worms.

Reporting their experiments to the journal, *Science*, the Wisconsin investigators say that their results give a scientific basis for the use of fresh pineapple juice as an anthelmintic or worm medicine. No directions for the use of this new remedy are given, but the test-tube experiments show that fresh juice must be used as heating destroys the anti-worm activity.

THE EQUINOXES

EDGAR H. WEBSTER, *Head of Department of Science (Retired) Atlanta University*

I

The lady accosted me in the post office and asked, "Is it true that at the equinox day and night are equal all over the earth?" I wanted to say "No" but that would have led to an explanation, so I said "Yes"; but the question led to an interesting study.

The Almanac states that the sun will cross the Equator at 6:13 A.M., September 23, E.S.T. This makes the time for us on Mobile Bay at 5:13 A.M., C.S.T. To most of us this seems to say that on this date, day and night will be equal all over the earth, each being 12 hours. "Day" in this sense means the time of light.

The Mobile *Register* reports daily the time of sunrise and sunset for Mobile. These readings for September 23 are:

Sunrise . . . 5:41 A.M. Sunset . . . 5:48 P.M. These figures make the time of daylight 12 h. 07 min. The time of darkness was 11 h. 53 min. Thus the day is 14 minutes longer than the night . . . a fairly sizable quantity.

The *Register's* report, "Sunrise at 5:41 A.M., September 23," raises the question as to the meaning of the reading. The government Tables of Sunrise and Sunset define "Sunrise" as "the instant when the true Zenith distance of the sun's center is 90 degrees and 50 minutes (of arc); 34′ being allowed for horizontal refraction and 16′ for the sun's semi-diameter. Sunrise for any observer depends upon his elevation provided he has an unobstructed view toward the east. There will be as many sunrises, then, as there are observers at different altitudes. That may be accurate enough for popular use, but not accurate enough for scientific purposes.

The factors, then, that enter into sunrise are: (1) the semi-diameter, and (2) the horizontal refraction. As regards the Equinox, the semi-diameter of the sun is the important factor.

The sun's semi-diameter being about 16′, its diameter is about 32′ or rather more than one-half degree. The sun moves about one degree a day through the heavens. This is about twice its diameter. Thus it takes the sun about 12 hours to cross the Equator. The statement above really means that "the center of

the sun will cross the Equator at 5:13 A.M., C.S.T., September 23, 1937."

If the sun were a point, then September 23 would be the true Equinox as regards day and night. It is the semi-diameter that complicates the problem.

As daylight and darkness were not equal on the 23d of September, we ask when were they equal. This table will be helpful:

	Sunrise	*Sunset*	*Daylight*
Sept. 22	5:40	5:49	12:09
23	5:41	5:48	12:07
24	5:41	5:46	12:05
25	5:42	5:45	12:03
26	5:43	5:44	12:01
27	5:43	5:43	12:00

The table shows that the "absolute" Equinox occurred on the 27th, or 4 days after the "astronomical" Equinox. What was the situation at the spring Equinox? The Almanac states that "the sun crosses the Equator at 7:45 P.M., March 20, E.S.T." On that date daylight was 12:07. On March 21 daylight was 12:09. Apparently the "absolute" Equinox precedes the "astronomical" Equinox. Again a table:

March 16	6:01	6:01	12:00
17	5:59	6:01	12:02
18	5:58	6:02	12:04
19	5:57	6:03	12:06
20	5:56	6:03	12:07
21	5:55	6:04	12:09

Thus in the spring, the "absolute" Equinox was on March 16, and preceded the "astronomical" Equinox by 4 days. This is the situation at Mobile, Alabama, Latitude 31 deg. N. What are the facts at Philadelphia, 40 deg. N.? Our Almanac gives the readings of sunrise and sunset at that city:

	Philadelphia		
March 16	6:11	6:07	11:56
17	6:09	6:08	11:59
18	6:07	6:09	12:02
19	6:06	6:10	12:04
20	6:04	6:12	12:08
21	6:03	6:13	12:10

Here in Philadelphia the day and night of 12 hours each seems to lie between March 17 and March 18, or (say) from noon of the 17th to noon of the 18th. The facts of the spring Equinox at Philadelphia are similar to those at Mobile, but the

figures vary. This leads to a study of the fall Equinox at Philadelphia:

Sept. 22	5:47	5:59	12:12
23	5:48	5:57	12:09
24	5:49	5:55	12:06
25	5:50	5:54	12:04
26	5:51	5:52	12:01
27	5:52	5:51	11:59

As with the spring Equinox, so with the fall Equinox, as the "absolute" Equinox falls between two days, the 26th and the 27th. Perhaps again from noon of the 26th to noon of the 27th.

II

As sunrise occurs at the instant the zenith distance of the center of the sun is 90 deg. 50′, sunset must occur under similar conditions. Thus it seems that daylight robs darkness at both ends. These readings are suggestive:

		Philadelphia		
March 20	sunrise 6:04	sunset 6:12	daylight gain	8 min.
Sept. 23	sunrise 5:48	sunset 5:57	daylight gain	9 min.
		Mobile		
March 20	sunrise 5:56	sunset 6:03	daylight gain	7 min.
Sept. 23	sunrise 5:41	sunset 5:48	daylight gain	7 min.

These readings are curiously near each other and seem to represent the gain of daylight or the loss of night to the theoretical 12:00 each at the Equinox if we could eliminate the semi-diameter of the sun and horizontal refraction.

The gain at sunrise for Mobile is about 3.5 min. and at Philadelphia about 4:25 min. And similar figures represent the gain at sunset. This gain must represent the time that elapses between the sunrise as defined above and the actual appearance of the upper limb of the sun above the astronomical horizon. The vertical distance being 34′, this would be about 2 minutes if the sun rose vertically. But the sunrise path is inclined to the horizon, the angle of inclination depending upon the latitude and the time of the year. This gain of daylight is therefore not a constant but a variable varying from a minimum when the sun is most nearly vertical as June 21 in the northern hemisphere, to a maximum when farthest from vertical as December 22.

III

A comparison of the times of sunrise of these two cities brings out an interesting relation, the dates being those of September (above):

Philadelphia	5:47	5:48	5:49	5:50	5:51	5:52
Mobile	5:40	5:41	5:41	5:42	5:43	5:43
difference	7	7	8	8	8	9

As Philadelphia has E.S.T. and is itself on the standard meridian, the 75th, this difference in time shows that Mobile which is 8 minutes earlier in C.S.T. is 2 degrees east of its standard meridian, that of New Orleans, or the 90th. Therefore the longitude of Mobile approximates 88 degrees west.

IV

As the spring Equinox is March 20, if the fall Equinox could have been September 20, and each month of 30 days, the sun would be north of the equator 180 days; but we must add to this an extra day in March, in May, in July, and in August, and 3 in September, so that the sun is 187 days north of the equator, and that leaves only 178 days for the sun south of the equator. As the North Pole is in sunlight 9 days longer than the South Pole, it will have 216 more hours of sunlight than the opposite pole and 108 hours more than a place on the equator.

The astronomical seasons for us in the northern hemisphere are: spring, from March 20 to June 21, 93 days; summer to September 23, 94 days; autumn to December 22, 90 days, and winter to March 20, 88 days. The seasons of the southern hemisphere are: spring 90 days, summer 88 days, autumn 93 days, and winter 94 days. That is, we in the northern hemisphere have 6 more days of summer and 6 fewer days in winter than our neighbors south of the equator.

V

In spring daylight is gaining upon night, and the equality is reached at the "absolute" Equinox before the "astronomical" Equinox; in the fall, night is encroaching upon daylight and the "absolute" Equinox follows the "astronomical" Equinox.

NOTE: The government Tide Tables for 1931 state: "The times of sunrise and sunset were computed for average declinations, and with the eye at an elevation of 15 feet above sea level or plane of land." This is probably the statement for all issues prior to 1931. The Tables for 1932 state: "The times were computed for the instant when the true zenith distance of the sun's center is 90 deg. 50′, 34′ being allowed for horizontal refraction and 16′ for semi-diameter. No allowance has been made for elevation of the eye."

EVALUATING THE INTANGIBLES IN ELEMENTARY SCIENCE

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The wise teacher, after having completed an area in elementary science, will ask himself, "How is all of this work measured?" "How am I to mark the pupils?" "How am I able to determined whether or not the goals that I have set are attained?" If in an elementary science program one is working towards the attainment of fuller meanings in the subject matter as well as the development of attitudes, skills, generalizations, etc., there must be some form of evaluation. Teachers say, "We want our pupils to become skilled in handling the materials appropriate to elementary science. We want them to develop certain attitudes, habits towards the truth, and so on." Yet little has been done by them to attain these objectives. It is true that teachers as a whole have made satisfactory tests that cover factual material, but for the wider, more intangible, and what seems to be more important aspects of the elementary science program, practically nothing has been done in the matter of measurement. Too often, teachers of elementary science have taken for granted that there has been growth in the child, that there has been some change in the child's behavior as a result of the teaching. But are they sure? How do they arrive at these conclusions? Have we not as teachers set up our objectives and then trusted that we have attained them? Have we not "reckoned" in our measurement? If we claim we are directing our teaching towards growth in the intangibles, should we not be honest with ourselves and discover some means by which we can assure ourselves that there has been growth? Some educators advocate that we can not measure the intangibles, while others are of the opinion that a method can be devised,[1] subjective in part.

Since some of the goals in elementary science are the development of scientific attitudes, the development of skills, and the application of generalizations, how can one go about testing for these intangible factors? Wrightstone, in his article, "Measuring the Attainment of Newer Education Objectives,"[2] ap-

[1] Hamalainen, A. H., "Evaluation in the Social Studies." *The Social Studies*, October, 1937, Vol. XXVII. no. 6, pages 250–52.

[2] Wrightstone, J. W., "Measuring the Attainment of Newer Educational Objectives." *National Elementary Principal*, Yearbook 16, pages 493–500. July, 1937.

pears to have suggested a procedure, which could well be utilized in evaluating the intangibles in elementary science.

Let us consider for evaluation an area of work which may be taught in an elementary science program, "Machines and their Implications." The shrewd teacher would clarify for her own thinking the aims or objectives previous to the teaching of the area. Certain changes in pupil behavior regarding concepts, knowledges, attitudes and appreciation, overt behavior and skills would then be determined. Tools or means by which the teacher would be able to determine changes in pupil behavior must be considered as well as the application of the evaluative instruments to show to what extent the behavior is present. The writer has attempted to illustrate how he would attempt the evaluation of the area, "Machines and their Implications," by utilizing the above mentioned technique.

EVALUATION CHART

Areas of Evaluation	*Tools Used*	*Typical Illustrations*
Concepts		
1. Our ways of living are affected by the use of machines.	Classroom tests	Problems
2. Man's intelligent endeavor has been a factor in our present civilization.	Work sheets	
3. Our society is affected by inventions.	Parent interviews	
4. Machine power is more efficient than man power.	Anecdotal records of pupil behavior based upon teacher observation.	
5. The era of machines has implications which are social.	Pupil logs or diary of the child's experience during the area of work.	
6. Human energy can be conserved by use of machines.		
Knowledges		
1. A knowledge that machines can do work more quickly, more easily, better, than man power.	Performance tests. Anecdotal records.	Experiments with simple machines.
2. Machines are a combination of two or more simple machines.	Pupil logs and pupil diaries.	Problems
3. Machines gives us more leisure time for recreation.		

Attitudes and Appreciations		
1. Pupils have respect for people who develop more efficient ways of doings.	Comparison of pre-tests and final tests covering attitudes and appreciation.	Statements about the unit of work by which the child can express what he believes.
2. An appreciation that the standard of living is higher because of machines.	Classroom tests.	
3. A recognition that society changes through the effect of inventions	Observations.	
Overt Behavior		
1. A desire to visit machines at work.	Excursions.	A visit to a nearby project under construction.
2. A desire to read and send for material about machines.	Anecdotal records.	
3. A desire to use simple machines.	Writing for source materials.	
Skills		
1. Use and construct simple machines.	Performance tests.	The construction of simple machines.
2. Organization of materials.	A classroom test based upon skills devised by the teacher.	
3. Manipulation of apparatus.		

TYPICAL ILLUSTRATIONS

Problems

Concepts

1. Imagine that three boys are coming to school. One boy walks to school. One boy roller skates to school. One boy uses a bicycle to get to school. The three boys start from the same place together. Draw three lines to show how far you think each boy would be after he had gone three street blocks.
2. Imagine that you are a primitive boy of long, long ago. Also imagine that you were able to come to visit a community of today. Show how you would have a change of ways in living.
3. Below is a line which shows the use of machines from the primitive man to the present time. On this line, shade the part which you think shows the most progress of machines made by man.

10,000 B.C. 1939

Primitive Man Modern Man

Knowledges

1. Cut an orange in half. Squeeze out the juice from one half with your hands. Take the other half and use a squeezer. Which was easier?
2. Using any means of expressing yourself, such as drawing a cartoon or a scene, or by writing a series of statements, show how machines have affected your life.

3. With the invention of machines, civilization has progressed. With this statement in mind tell why your home, your community is different from the home, the community of early man.

Attitudes and Appreciations

In constructing tests in attitudes it might be well to use general statements in the pre-tests, and in the final test use statements that would show shades of meaning regarding the attitude or appreciation.

In this test are statements which you can check as you think. Put the check (√) in the column to show what you think.

Sample Statement	Agree Strongly	Agree	Undecided	Disagree	Disagree Strongly
Machines make work easy.					
1. Machines put people out of work.					
2. Machines change one's way of living.					
3. Machines do work better than man.					
4. People who invent new machines should be put in jail.					
5. Machines cause many accidents.					
6. We enjoy many luxuries because of machines.					
7. Machines cause pollution in our community which is bad for our health.					
8. Machines have speeded up a person's life. Thus he will not live long.					
9. We need less time to make things when we use a machine.					
10. Machines make things better than hand made things.					
11. Machines have given man much leisure time.					
12. Machines have raised our standard of living.					

Overt Behavior

The anecdotal record appears to be the best tool to measure changes in pupil behavior regarding overt behavior. There are three types of anecdotal records. One may be a word picture of the child in action, another a record of observation with an explanation, and still another a record of observation accompanied with recommendation. Below are typical observations which were recorded daily for a period of a week. Anecdotal record of John Doe.

Jan. 9 John found a book which had material that Mary needed and called her attention to it. He remarked near the end of the period that he had seem a real machine such as the one that was illustrated in the book he was reading.
Jan. 10 John decided upon his project and told the teacher about it.
Jan. 11 John brought material from home to work on his project. He remarked to Bill, "This is a lot harder to make than I thought." John consulted his reference book quite a bit during the period.
Jan. 12 John came to the teacher for advice. He seemed interested but not as enthusiastic as he was in the beginning.
Jan. 13 John needed help today. He seems to be losing his interest.

Skills

In this test a basal text that is used in the unit or a reference book which has information about the unit is to be consulated.

In making tests in skills, caution should be taken to use statements which will show to what extent the development of the skill has been attained.

Below are statements which can be answered by using the above sources. After each statement is a blank. Write in the word or number which will answer the question.[3]

SAMPLE STATEMENT: Is there any information in the book about machines? *Yes*

1. On what pages will you find information about machines? .....
2. Does the index tell you that there is something in the book about machines? .....
3. Under what topic will you find information about machines? .....
4. Does the index list separate machines? .....
5. How many kinds of machines are mentioned in the book? .....
6. Can you find simple experiments to do in the book? .....
7. Does the book show many pictures of machines at work? .....
8. Can you find information in the book about some of the machines that are used in your home? .....
9. Does the book give some questions which you can answer? .....
10. On what page will you find an example of the seesaw? .....

[3] Source book for this test—Beauchamp, W. et al. *Discovering Our World, Book 2*, Scott, Foresman & Company. 1938.

In the attempt to clarify the chart, the writer has offered typical illustrations of various tools or means of measurement suggested which include type of questions to be used in the classroom tests.

Needless to say, teachers of elementary science should attempt to evaluate to what extent the "intangibles" result from the teaching of any area of science. Would not the teacher have some means whereby he could be assured that his aims and objectives have been attained? Would not the teacher have, perhaps, tangible evidence of changes in pupil behavior regarding the attainment of the "intangibles"? Whether the teacher follows the procedure that has been mentioned or devises a form of his own, he has then not only directed his teaching towards certain values but also made an attempt to discover if he accomplished those values.

When the teacher of elementary science seriously considers the problem of evaluation in his teaching as growth in intangibles objectives, the goals in which he is striving are more clear to him and likewise to his pupils. There seems to be but little question that evaluation will remain and continue to be of importance in the newer methods of teaching. In spite of the fact that the evaluation is often subjective, the refinement of the methods that are beginning to be used suggests that the validity and reliability of these measures are becoming increasingly more significant. If we are to improve science teaching and aid child growth and development, and if the science program is to be justified we must have an accumulation of evidence bearing on the growth of the child that will substantiate our claims of the value of elementary science. Thus, in elementary science, evaluation is important and mut be a part of the program. It must be dynamic and everchanging, adaptable to the varying interests and abilities of the group to whom we are administering our program.

INVESTMENT IN EDUCATION

The United States Office of Education estimates that the Nation's investment in educational plants and endowments and other trust funds is more than $12,000,000,000. Of the endowment and trust funds about $1,525,000,000 are held by private institutions and $712,000,000 by public institutions.

AIMS OF THE LABORATORY

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Most readers of SCHOOL SCIENCE AND MATHEMATICS are acquainted with the results of studies made from time to time in an effort to evaluate the lecture, textbook and laboratory methods of instruction in science. Summaries of these studies seem to indicate that there is not so great difference as is ordinarily supposed in the values of the three methods, *so far as imparting knowledge is concerned*. The laboratory method which demands more expenditure of time and of money can best be defended by reference to the so-called intangibles. If this be true, it follows that the most efficient and most valuable type of laboratory instruction is based on certain oft-repeated objectives.

Unfortunately, there is far too much laboratory instruction without clearcut appraisal and application of the aims. Most teachers unconsciously strive for goals which remain hidden in a welter of confusion. If they would take time to crystallize their aims into a formula of action, the superiority of the laboratory method would be clearly evident.

Lest we forget some of these worthy aims or wish to crystallize others, allow me to suggest the following list for teaching by the individual laboratory method.

1) TO HAVE THE PUPIL PLAN A COURSE OF ACTION BEFORE BEGINNING ANY WORK—clear, carefully organized thoughts before action. The teacher should hold the pupil responsible for having a clear, well-defined goal and for knowing the specific processes and procedure that he plans to use to attain this goal. It might be well to have the pupils write out an outline of this procedure, in a few instances, so that they will feel the responsibility of a definite scheme. A plan is of advantage in doing anything which requires complicated skill; i.e., driving an automobile, cooking, baking, or in construction work. The teacher should make an effort to establish a transfer of this method into fields other than science.

2) TO CONFRONT THE PUPIL WITH A NEW ENVIRONMENT—a new type of experience which requires new terminology, novel tools, and a shift of emphasis. This aim can be divided into the following:

a) TO GIVE THE PUPIL AN OPPORTUNITY TO USE INDIVIDUAL RESOURCEFULNESS AND INITIATIVE.

b) TO GIVE THE PUPIL AN OPPORTUNITY TO MAKE ERRORS AND TO SEE HOW THE RESULTS ARE AFFECTED.

c) TO DEVELOP SELF-CONFIDENCE IN THE PUPIL. The pupil experiences the thrill, satisfaction and confidence in accomplishing something with his own hands and by his own thinking.

d) TO EXPERIENCE THE THRILL OF DISCOVERY by a well-planned unit which involves some re-discovery; e.g., seeing the craters on the moon, developing Archimedes' principle. Although considerable thought and preparation is required on the part of the teacher, this method often results in giving the pupil lasting impressions and an exhilarating experience which he so rarely gets through other methods of approach.

3) TO GIVE THE PUPIL DIRECT AND VALID VOCATIONAL GUIDANCE. Vocational guidance, by the laboratory method, is not passive, vicarious experience, but rather active and first-hand. It offers the pupil a chance to try being a scientist—to know the smell of a laboratory—to see and use the scientist's tools—to be confronted with laboratory problems and to try solving them by himself. Above all, he should sample the emotional feeling that is concomitant with the vocation.

4) TO GIVE THE PUPIL A FULLER UNDERSTANDING AND APPRECIATION OF THE TASKS AND ACHIEVEMENTS OF THE LABORATORY WORKER. Through the laboratory work the pupil will come to realize the patience, effort, skill and intelligence that is required to make scientific advances.

5) TO HAVE THE PUPIL CONSCIOUS OF THE LIMITATIONS OF THE EXPERIMENTAL METHODS; i.e., the experimental error and the difficulty that is encountered in trying to control conditions. The pupil should have some definite notion as to what are significant figures, both in writing up his experiments and in interpreting data; i.e., stellar distances, the size of microorganisms, the size of the atom, etc. The pupil should not only realize the difficulty in controlling conditions, but also how radically the results may be affected when conditions are not controlled. The pupils should also realize that much of the confusion of the social sciences is due to the difficulty encountered in attempting to control conditions.

6) TO STRENGTHEN THE BOND BETWEEN THEORY AND PRACTICE. When written directions are required, they should have fuller meaning to the pupil, and this meaning should be intimately related to actions. The laboratory gives the pupil a chance to interpret and apply directions. The pupil interprets

the directions and certain other written material not merely in terms of verbal symbols but also in terms of action.

7) TO EXERCISE PATIENCE, COURAGE AND PERSEVERANCE THOUGH THE SUCCESS MAY NOT BE IMMEDIATELY EVIDENT. This trait is certainly a valuable aid in the struggle in our modern world. Yet all too many youths become discouraged very easily, especially when they are not realizing success. Laboratories are well adapted for giving pupils this sort of ability. Not only does the pupil feel inherently more of a responsibility to finish an experimental problem, but also, he is given opportunity to work diligently on a problem, the outcome not being known until the work is finished.

8) TO CORRECT THE UNDESIRABLE INDIVIDUAL DIFFERENCES. In nearly all kinds of study, the mental workings are secretive and very difficult to analyze, for at most, the pupil puts down only the results of his thinking. However in the laboratory almost every mental act is accompanied and revealed by a physical act. Thus the teacher has a splendid opportunity to note the individual differences in the working of the pupils' minds—how clear-cut the ideas are, and the accuracy, logic and sequence of their minds. After observing the pupils at work the slower ones can be given remedial suggestions. These suggestions are relatively easier to administer and easier to comprehend.

9) TO DEVELOP A SENSE OF ACCURACY, at least in weighing, measuring, observing and following directions. Of course, it is hoped, and an effort should me made, for transfer of training, (but this is expecting a great deal).

10) TO APPRECIATE AND PRACTICE GENERAL CLEANLINESS AND ORDERLINESS in scientific work (again hoping and working for a carry-over into other fields). This aim is concerned with having materials in their respective places and general cleanliness during and after work. The absolute necessity for these factors is realized by the laboratory worker. Laboratory situations should be presented to the pupil in which he will be led to realize the necessity for cleanliness and orderliness.

11) TO GIVE THE PUPIL A MORE INTIMATE UNDERSTANDING OF THE SCIENTIFIC MATERIALS AND TOOLS. In the laboratory the pupil has the opportunity to receive impressions through many senses. Thus the scientific object has a fuller meaning because of the increased number of associations that are formed in seeing, smelling, touching and using it. Ample time should be given for the pupil to have his curiosity about the materials satisfied.

12) TO ACQUIRE SOME SPECIFIC LABORATORY TECHNIQUES. There is a satisfaction which comes to a student as he carefully and skillfully handles glassware, controls a gas flame for best results or weighs and measures small quantities of materials. Even the most careless and indifferent member of the class is found to acquire an increased feeling of responsibility for equipment which is entrusted to his care.

COMMON PUPIL DIFFICULTIES WITH BASIC CONCEPTS OF LOGARITHMS

HARRY T. PILLANS
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Probably most pupils in high school who study trigonometry have difficulty with certain concepts concerning logarithms of decimal fractions, to wit:

(a) The apparent incongruity of negative characteristics and positive mantissas.

(b) The true nature of the operation of the division of such a logarithm by the index of a root.

(c) The meaning of the logarithm of such a logarithm.

(d) The confusion of conceiving a logarithm as an exponent that requires that the base be taken a fractional number of times as a factor.

These will be discussed in the above order in a manner that should be intelligible to the high school pupil; a rigorous treatment is not intended.

(a) The apparent incongruity of negative characteristics and positive mantissas.

The usual text-book explanation is as follows:

$10^3 = 1000$, therefore $\log 1000 = 3.0000$
$10^2 = 100$, therefore $\log 100 = 2.0000$
. . . . . .
$10^{\bar{3}} = .001$ therefore $\log .001 = \bar{3}.0000$

And there they leave it.

Suppose, however, the decimal fraction whose logarithm is to be found is not a unit fraction like 1/10, or 1/1000, but is a fraction such as .342, or 342/1000. Here we encounter the difficulty referred to.

Let $x = .342$, (or $342/1000$, or $342 \times 1/1000$)
Then $\log x = \log 342 + \log 1/1000$

$$
\begin{aligned}
(1) \qquad &= 2.5340+(-3.0000) \\
&= 2.0000+.5340-3.0000 \\
&= -1.0000+.5340 \\
(2) \qquad &= \bar{1}.5340
\end{aligned}
$$

This logarithm is simply the *indicated* addition of a negative integer and a positive decimal fraction less than unity. If we perform the indicated addition we have, from (1) -3.0000 or

$$
\begin{array}{r}
+2.5340 \\
\hline
-0.4660
\end{array}
$$

from (2) -1.0000

$$
\begin{array}{r}
+\ .5340 \\
\hline
-0.4660
\end{array}
$$

In other words, the logarithm of .342 is really negative in its entirety, as a little reflection would show it would have to be inasmuch as .342 is less than unity and the log 1 is zero. Now if we add $10-10$ (or 0) to the log we will not change its value but will merely change the form in which it is expressed:

$$
\begin{array}{r}
10.0000-10 \\
-0.4660 \\
\hline
9.5340-10
\end{array}
$$

which is the same as $\bar{1}.5340$ in (2).

This gives us the customary form in which the characteristic is negative and the mantissa positive, the form that permits of entering a table of logs (in which all mantissas are positive) and finding the mantissa directly. Calculation of the product of several factors and of more involved expressions is facilitated because all logs can be added in a single column, which could not be done if some logs were positive and some negative. It is thus seen that this customary form of writing such a logarithm is merely a matter of convenience—simply writing it as the indicated sum of a negative and a positive number instead of a single negative number—purely for greater ease in use of tables and in manipulation.

(b) The true nature of the operation of the division of such a logarithm by the index of a root.

To illustrate, find x if $x=\sqrt[3]{.342}$

$\log x = 1/3 \log .342$

Now $\log .342 = \bar{1}.5340$

Dividing by 3 gives us: $1/3 \log .342 = \bar{1}/3\ .1780$ because $\bar{1}.5340$ is of the form $(-a+b)$ and $1/3\,(-a+b) = -1/3\,a+1/3b$. And certainly this is in accordance with the laws of exponents.

The explanation is simple: $\bar{1}/3$ .1780 means $-1/3+$ .1780

Combining these: $-.3333$

$+.1780$

$-.1553$

This is a negative logarithm which, expressed in the usual form is $9.8447-10$. It now becomes apparent that in the usual procedure we merely add and subtract 10 or an appropriate multiple of 10 *before* making the division in the interests of simplification, instead of doing it later as in the above illustration. In this case, employing the usual method:

$\log .342 = \bar{1}.5340$

$= 29.5340-30$

Bearing in mind that this means $+29.5340-30$ division by 3 results in the equation $1/3 \log .342 = 9.8447-10$, the same as above.

(c) The meaning of the logarithm of such a logarithm.

For example, find log log .342

$\log .342 = 9.5340-10$, or $\bar{1}.5340$

As previously explained this is not a single number, but the indicated algebraic sum of two numbers, and hence must be expressed as a single number before we can enter a log table to extract its log; that is, it must be shown in its true colors as -0.4660. The negative sign need give no concern, as in computations by use of logarithms the algebraic signs of factors are ignored in consulting the tables and considered only in arriving at the sign of the final result, an odd number of negative factors giving a negative final result, an even number a positive.

(d) The confusion of conceiving a logarithm as an exponent that requires that the base be taken a fractional number of times as a factor.

The pupil's trouble here is over-simplification. An exponent indicates the number of times the base is taken as a factor: if a number is squared it is taken two times as a factor; if cubed, three times. But how, he asks, can a number be taken a fractional number of times as a factor? He loses sight of the fact that the logarithm expressed as a decimal fraction *is in reality* a fraction—the exact or approximate decimal equivalent of a fraction whose numerator is an integer indicating the power and whose denominator is an integer indicating the root, and that neither the laws of exponents nor his conception of factors are violated.

MISPLACED MATHEMATICAL RECREATIONS

M. C. Bergen
Morgan Park Junior College, Chicago, Illinois

Educators are giving increasingly more attention to so-called recreations in mathematics as a means of stimulating interest in the subject on the part of pupils. For the most part they agree that to some extent the students are motivated by such devices. Mathematics teachers are incorporating these devices into their regular teaching procedures. No doubt some brain-twisters, some tricks and puzzles are beneficial, but there is always the danger of over-emphasis, of poor choice of problems, of going to extremes, the latter a definite weakness among the members of our profession.

The writer has listened, with misgivings, to two addresses on this subject, at two different junior college conferences, delivered by two experienced women teachers. The speakers were enthusiastic. They were certain that a strong interest in mathematics could be aroused by injecting into the daily class-room procedure, such devices as mathematical tricks, trick problems, brain twisters, puzzles, and what not. But they are overlooking certain fundamental difficulties. They are headed for disaster unless they proceed more cautiously.

At the high school and junior college levels there are only two groups of students from the standpoint of mathematics; namely, those who are interested in mathematics, and those who are not. The first group needs no motivating. The possibility of learning more mathematics is enough for them. They present no pressing problem to the teacher. The difficulties arise within the second group. They are the pupils to be motivated. Will tricks and puzzles do it?

In the first place, many pupils in the second group enter their mathematics classes with fear and trembling. They do not understand the fundamental processes, they cannot work simple problems, they have to work very hard to keep up with the class. Certainly trick problems, such as the type that requires the discovery of a division by zero, or the extraction of the square root of a negative number to uncover the fallacy, will mean nothing to them. Such problems will be solved by pupils of the first group, the very ones who do not need the motivation.

In the second place the pupils of the second group cannot see much concreteness or logic in mathematics. They have been

told that mathematics is basically logical and concrete, but they do not see it. They don't see why a number is positive on one side of an equation and negative on the other. They don't see why little curved lines are placed around some expressions and not around others. They see no concreteness in taking a lot of (to them) meaningless words, writing an equation to represent them, and then solving for X. To one who does not understand them such things are not concrete, they are not logical. They seem rather to be mysterious, to be understood only by the enlightened few. Will puzzles help them? How can a problem purposely worded to be tricky and evasive look concrete to them? Will they not be even more convinced that mathematics is not concrete, that it is entirely lacking in logic, that it takes a peculiar type of mind to solve such problems?

One of the problems advocated by a speaker previously referred to was of the type well known to most of us. A farmer has to cross a river with a fox, a goose, and a bag of grain. He can take only one of these articles at a time. Which two is it safe for him to leave behind together on his first trip? Which two will it be safe for him to leave together on the opposite side for his last trip? Is such a problem logical? Will the thinking student not wonder how the farmer managed the overland trip up to the river with such a company? Is not such a problem really ridiculous? Probably it is fun for some people to iron the thing out, but to the pupil not particularly interested in mathematics—and just how such a problem can be called mathematical is a question—it is merely further proof that mathematics is a senseless jumble, tricky, illogical.

The two groups of students under discussion are not equal in numbers. Mathematics teachers know that at the beginning of the year, for every interested pupil there are five or more who are not interested. We owe something to both groups. The interested pupils must be taught to work at full capacity, they must be trained to be leaders. Tricks and puzzles will be interesting to them and they should have them. But the proper place for them is in the mathematics club, usually attended by members of their group. There such problems are valuable and much good work is being done in our mathematics clubs. The other pupils cannot be aided by puzzles. The subject is puzzle enough. Their valuable time should not be wasted on such frivolities. Better to show them the relationships among the various branches. Better to show them logically, the logical processes of

mathematics, with logical, concrete problems. These things are more apt to motivate an interest. Once interested they pass from this group into the other. Time enough then for puzzles, but certainly the classroom is no place for them. Practice in puzzle solving makes for proficiency in puzzle solving, but in nothing else.

POINTS WHERE THE ARITHMETIC TEACHER CAN PREVENT ALGEBRA DIFFICULTIES

C. R. PURDY
Joseph Sears School, Kenilworth, Illinois

The teacher of arithmetic teaches a subject which itself meets specific needs. In our present school set up there is, however, the added responsibility of building a foundation for mathematics which is to follow in the secondary school. With this second objective in mind, I would like to list three "don'ts" for the arithmetic teachers, which will avoid confusion and "unlearning" at a higher level.

The first of these is: Do not use signs of process in practice exercises, particularly subtraction. The processes with signed numbers in algebra are complicated by the well developed habit of prefixing the subtrahend by a minus sign in all subtraction exercises. This objection is easily avoided by directing the arithmetic process by use of the word subtraction rather than the sign in the case of vertical subtraction.

The second thing to avoid is the use of formulas with multiplication and division signs rather than the accepted practice of writing a multiplier adjacent to the multiplicand and divisors in denominators. An example of the former is the formula for the area of the trapezoid given in some of the newer arithmetic texts in the form $A=\frac{b+b'}{2}\times h$. The form of the formula using parentheses is the form in which it will be encountered in the literature and in which this and similar formulas will be used in the future. The point may seem insignificant, but it seems to be encouraging a type of equation and formula writing which is to be unlearned in the future. In my experience, the parenthesis can be readily understood at the eighth grade level, so why teach one thing there and a different form the following year? It seems, further, that the type of mistake which produces $x+y\div 2$

as the expression of half the sum of x and y, may very possibly be encouraged by permitting the use of the $\div$ and $\times$ sign in algebraic expressions.

Another place where the arithmetic teacher can avoid complications in later mathematics without causing undue hardship in the junior high school years is in evaluating formulas. In the more complicated formulas of science and many branches of mathematics, one cannot look at the facts and write down the answer without a very definite process of evaluation. Hence it seems reasonable to learn at an early age the steps of writing the formula, writing the known facts, substituting in the formula, and reducing the resulting expression. In finding the area of a rectangle it may seem like needless drudgery, but if the process is definitely learned there, the work with volumes of solids and more complicated formulas seems to progress with considerably greater accuracy.

These are just three of the numerous places where the arithmetic class can build for following mathematics work without detracting in the least from the subject of arithmetic. Certainly there is some responsibility for training for mathematics along with the training for uses on the arithmetic level.

HIGH LIGHTS OF THE NOVEMBER SKIES

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DAVID W. RUSSELL
National College of Education, Evanston, Illinois

[EDITOR'S NOTE—In view of the increasing interest in star gazing and telescope making in schools, SCHOOL SCIENCE AND MATHEMATICS begins in this issue a series of constellation maps for ready reference. If these articles are saved from month to month they will make a convenient handbook of star charts and school activities. Teachers who have conducted successful activities with children in this field are invited to send their suggestions to the authors for publication in these articles.]

"One sun by day, by night ten thousand shine . . . ." well describes the brillance of November skies. The following chart will help to locate some of the ten thousand that shine. The chart should be held overhead with north to north and south to south to locate the constellations in their apparent positions. Only the stars with the lowest magnitude and the constellations most commonly known are included in the ready reference map.

I. CONSTELLATIONS AND STARS

A good starting place in the November skies is to find the constellation

Pegasus, the snow-white winged horse of legendary significance. It is quickly recognized by the configuration known as the "Great Square of Pegasus" in the overhead skies. The principal star in *Pegasus* is *Markab*. The star in the northeast corner of the square is *Alpheratz* but is in the constellation *Andromeda*, in legend, the daughter of Cepheus and Cassiopeia. Particularly significant in the constellation *Andromeda* is the spiral nebulae which is said to be the most distant phenomena that can be detected with the unaided eye. It is supposed to be over 900,000 light years[1] away!

Directly east is *Taurus*, the bull, bringing the "Seven Sisters of the Pleiades" into full view. Only six of the seven sisters are plainly visible, and are sometimes confused with the "little dipper" or the constellation *Ursa Minor* which is far away in the northern sky. The brightest star in *Taurus* is *Aldebaran*, recognized by its brilliance and reddish color. This is a third magnitude star and has been estimated to be about fifty-six light years away.

Going north over the celestial ecliptic across the Milky Way is *Auriga*, the charioteer with the whip, goat, and kids, which can be easily recognized by its brilliant star, *Capella*, one of the monitors of the November sky. The star appears double through ordinary binoculars and its green and red twinkles make it a sight of real significance.

Drifting west and a little south is *Perseus*, in all its glory, forming the letter A. Its important star is the variable *Algol*, about 120 light years away. The star appears as one but is really two stars which eclipse each other every two days and twenty-one hours.

Cassiopeia, sometimes called the "Flying W" or "Cassiopeia's Chair," is a little north of overhead and is easily identified by the five bright stars forming an irregular W. The brightest star is *Schedir* with a magnitude of about 2.5 and approximately two hundred light years away! *Cassiopeia* is visible from points in the northern hemisphere throughout the year.

Leaving the "Flying W," westward through the Milky Way is *Cygnus*, the swan, easily distinguished by its brighter stars which form the "Northern Cross" or the "dagger." Its bright star is *Deneb* which radiates at the peak of the cross or near the top of the handle of the dagger. *Deneb* is a distant star, estimated to be about six hundred and fifty light years away.

North and west of the Northern Cross is the constellation *Lyra* named for the lyre, the harp-like instrument invented by the Thracian musician Orpheus. Its principal star *Vega* is about twenty-five light years away and appears to man as the second brightest star in the northern celestial hemisphere.

Going south, just leaving the Milky Way near the western horizon is *Aquila*, the eagle, brought into prominence by its bright star *Altair*. The three stars, *Deneb*, *Vega*, and *Altair* form what is sometimes called the "Great Northern Triangle."

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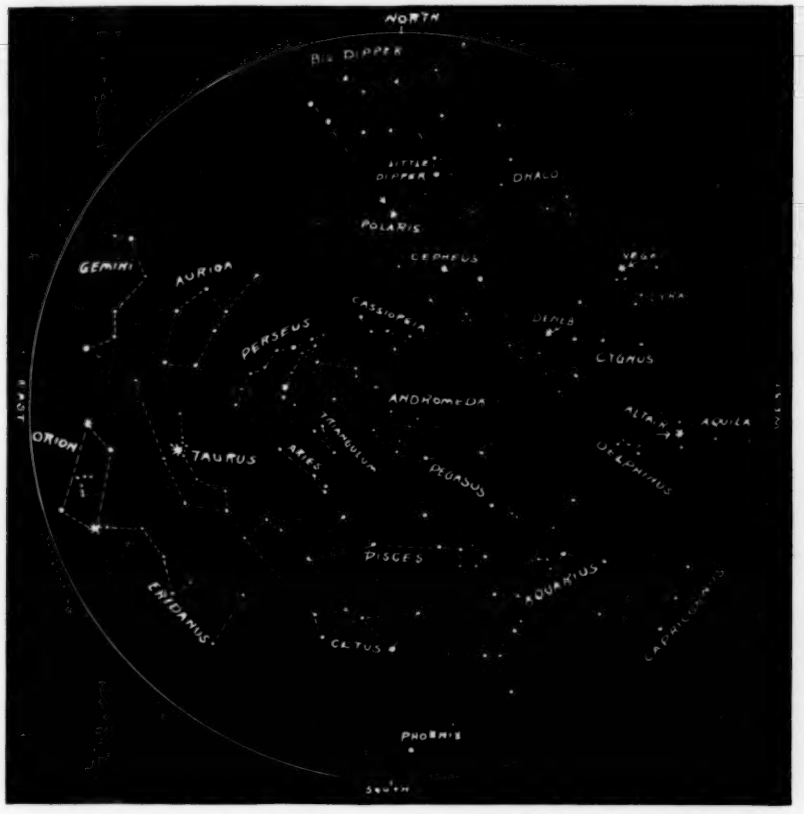
[1] A light year is the distance light is calculated to travel in one year or about six trillion miles.

Other constellations and stars are visible in the November skies. *Ursa Major*, the big bear, *Polaris*, the pole star in *Ursa Minor*, *Aquarius*, *Capricornus*, and *Pisces*, are easily recognized by using the star chart. When these "land marks of the sky" have been located, a more detailed chart should be obtained to find some of the stars with greater magnitude.



November 15—8 to 10 P.M.
November 1—9 to 11 P.M. November 30—7 to 9 P.M.

II. Planets and Shooting Stars

Star gazers are lucky in November for five of the major planets are in view. *Jupiter* with her moons, the rings of *Saturn*, *Venus*, sister planet to the earth, *Mercury* and *Mars* will be on hand! On Thanksgiving night the periodic meteoric showers radiating from *Andromeda* may sprinkle the sky with fire balls. November is a good month for star gazing, a month of five planets![2]

[2] American Nautical Almanac for the Year 1939, United States Naval Observatory, Washington D.C., gives astronomical data about the skies.

III. Classroom Activities

There are many plans for demonstrating astronomical facts to classes and devices that can be purchased or made in the school.[3] Visits to local observatories are among the best of these activities. Many observatories have weekly "open night" for the public. Student who peer through the telescope for the first time are often disappointed for the great spectacles often anticipated are not forthcoming. Viewing the moon is one of the best sights for the beginning classes and next best is looking at planets, especially *Saturn* with its mysterious rings, and the moons of *Jupiter*, and *Mars*. Then, too, the constellations of November with their legendary and mythological tales provide motivation for interesting and fascinating reports. Making reflector-type telescopes[4] is an activity being conducted in many schools this fall. It is an activity that involves many skills and scientific principles utilize much of the modern theory that has been expressed concerning modern science teaching.

Next month in "High Lights of the December Skies" more space will be devoted to the planets and specific activities as only a few new constellations will appear. The "Star of Bethlehem," the well-known symbol of Christmas, will also be discussed from an astronomical point of view.

[3] Porter, William A., "Demonstrating the Tip of the Earth as a Cause of Seasonal Change," School Science and Mathematics, XXXIX (April, 1939), pp. 323–324.

[4] Instructions for making telescopes are given in the illustrated booklet *Telescope Making*, published by School Science and Mathematics, 3314 North Fourteenth Street, Milwaukee, Wisconsin.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problems, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known reference to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

1610. *Proposed by C. W. Trigg, Los Angeles.*

There is a set of five digits whose sum is eight, and which has two permutations whose squares contain no duplicate digits. Find the set and identify the permutations.

Solution by Proposer

Since $N \equiv 8 \pmod 9$, $N^2 \equiv 64 \equiv 1 \pmod 9$, so $102345679 < N^2 < 976543210$ and $10116 < N < 31250$. If no duplicate digits are to appear in a nine-digit square neither the first, last, nor the three middle digits of N may be zero. Hence N must be within the indicated range and must be a permissible permutation of one of the thirteen sets 00116, 00125, 00134, 00224, 00233, 01115, 01124, 01133, 01223, 02222, 11114, 11123 or 11222. There are 153 possible values of N which result from these sets. The last four, and in general, the first four digits of N^2 can be read from Barlow's tables. Duplicate digits are thus revealed in all but seven instances, 22211, 20213, 23201, 31211, 10133, 21401, 10124, and 10214. When these are squared, the required solutions are found $(10124)^2 = 102495376$ and $(10214)^2 = 104325796$. None of the other five possibilities contains distinct digits in N^2.

Solution was also offered by J. M. Maxey, Wilmore, Ky.

1611. *Proposed by I. N. Warner, Platteville, Wis.*

How many board feet in a stick 16 feet long with parallel rectangular ends, one 4 in. by 4 in., the other 2 in. by 2 in.?

Solution by P. H. Renton, Trafford, Pa.

This stick is a frustrum of a regular square pyramid. The altitude of the frustrum is 16 feet or 192 inches, and the areas of the bases are 4 square inches and 16 square inches. The volume of the frustrum is given by

$$V = \tfrac{1}{3}h(B + B' + \sqrt{BB'})$$

where h is the altitude and B, B' are the base areas. By substitution,

$$V = \tfrac{1}{3}(192)(4+16+64) \quad \text{or}$$

$$V = 1792 \text{ cubic inches.}$$

Since 144 cubic inches = 1 board foot, there are 12 4/9 board feet in the stick.

Solutions were also offered by C. W. Trigg, Los Angeles, W. R. Smith, Chicago, and from Upper Canada College, Toronto, R. W. Baldwin, Malcolm K. Nelles, R. P. G. Thomson and H. J. M. Watson.

1612. *Proposed by John P. Hoyt, Cornwall, N. Y.*

ABC is an equilateral triangle with side 7. D is a point on AB at a distance 2 from B. DE is a line through the centroid of the triangle, E being the point where this line intersects AC. Find the length of EC.

First Solution

By S. E. Field, Ironwood, Michigan

Take as the vertices of the triangle the points $A(0, 0)$, $B(7, 0)$, and $C(7/2, 7\sqrt{3}/2)$. D on AB has coordinates (5, 0), and M, the centroid, is the point $(7/2, 7/2\sqrt{3})$.

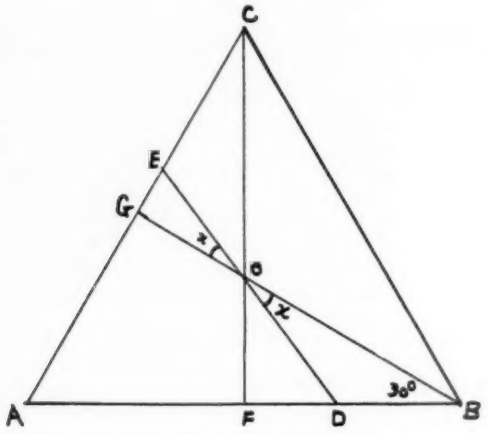
The equation AC is $\sqrt{3}\,x - y = 0$, and the equation of DE is $7x + 3\sqrt{3}y - 35 = 0$.

From these, the coordinates of E are found to be $(35/16, 35\sqrt{3}/16)$ and $EC = 21/8$.

Second Solution

By A. Mac Neish, Chicago, Illinois

Let O be the centroid, COF and BOG the medians to AB and AC respectively, $\angle x$ the angle between BG and DE. $\angle ABG$ is 30°.



$$BG=\frac{7}{2}\sqrt{3}, \quad BO=\frac{2}{3}BG=\frac{7}{3}\sqrt{3}, \quad \text{and} \quad GO=\frac{1}{3}BG=\frac{7}{6}\sqrt{3}.$$

Using ΔODB and the law of cosines

$$OD^2=BO^2+BD^2-2BOBD\cos 30°=\frac{19}{3}, \qquad OD=\frac{\sqrt{57}}{3}$$

$$\cos x=\frac{OD^2+BD^2-BD^2}{2\cdot OD\cdot BO}=\frac{4}{\sqrt{19}}$$

$$\sin x=\frac{\sqrt{3}}{\sqrt{19}}, \qquad \tan x=\frac{\sqrt{3}}{4}.$$

In ΔOGE, $\tan x=\dfrac{GE}{OG}$, $\quad GE=OG\tan x$, $\quad GE=\dfrac{7}{6}\sqrt{3}\,\dfrac{\sqrt{3}}{4}=\dfrac{7}{8}$.

Therefore $\quad CE=CG-GE=\dfrac{7}{2}-\dfrac{7}{8}=\dfrac{21}{8}=2\frac{5}{8}$.

EDITOR'S NOTE: The proposer quotes the following theorem, which is not well known, from which immediately he secures the result:

A line through the centroid of an equilateral triangle divides the two sides which it intersects into segments such that the ratio of the segments on one of these sides plus the ratio of the segments on the other side equals unity. Since D divides BA in the ratio 2/5, the point E must divide CA so that CE/EA equals 3/5. Consequently, CE is 3/8 of 7 or 2 1/8.

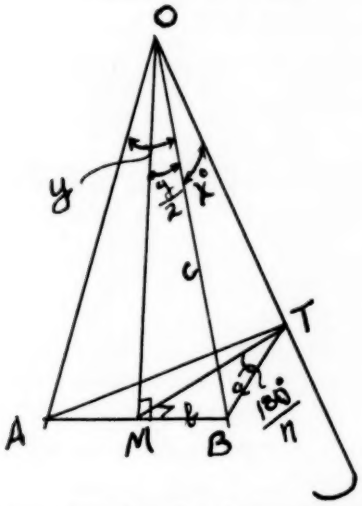
Solutions were offered by W. R. Smith, Chicago, Walter R. Warne, Romulus, N. Y., C. W. Trigg, Los Angeles, John F. Wagner, Chicago, P. H. Renton, Trafford, Pa., M. Kirk, West Chester, Pa., B. Felix John, Pittsburgh, D. L. Mac Kay, New York, Ralph Roberts, East Varick,

N. Y., J. Wilford Jacks, Geneva, N. Y., James G. Go, Cebu Cebu, P. I. From Upper Canada College, Toronto, solutions were sent by R. W. Baldwin, John R. Henderson, T. E. Hull, S. A. G. Singer and H. J. M. Watson.

1613. *Proposed by Winfield M. Sides, Andover, Mass.*

Deduce a formula to find the angle between two successive ribs of an umbrella of n straight ribs if each rib makes an angle of x with the center stick.

Solution by Proposer



OA and OB are two successive ribs of an umbrella that make an angle of x with the center stick OT. Drop OM perpendicular to AB and then draw MT.

Let y represent the number of degrees in the angle between the two successive ribs.

Triangles OMB, OTB, and BMT are right triangles.

$$\sin\frac{y}{2}=\frac{b}{c},\quad b=a\sin\frac{180}{n}\quad\text{and}\quad c=\frac{a}{\sin x}$$

$$\therefore\quad \sin\frac{y}{2}=a\sin\frac{180}{n}\div\frac{a}{\sin x}=\sin\frac{180}{n}\sin x\quad\text{and}$$

$$y=2\sin^{-1}\left(\sin\frac{180}{n}\sin x\right).$$

Solutions were also offered by James Wishlinske, Boys Technical H. S., Milwaukee, Wis., M. Kirk, West Chester, Pa., C. W. Trigg, Los Angeles, W. R. Smith, Chicago, John F. Wagner, Chicago.

1614. *Proposed by Willis Waggoner, Syracuse, New York.*

Solve for x and y:

$$\left(3-\frac{6y}{x+y}\right)^2+\left(3+\frac{6y}{x-y}\right)^2=82$$

$$xy=2.$$

Solution by Hazel C. Jones, Danville, Ill.

By changing the mixed expressions to improper fractions, simplifying, expanding, clearing of fractions, and combining like terms, the first equation becomes

$$4x^4-17x^2y^2+4y^4=0$$

which by factoring reduces to

$$(2x+y)(x+2y)(x+2y)(2x-y)=0.$$

Solving this equation with the second equation, $xy=2$, the complete solution consists of the eight pairs of values

$$(\pm 1, \pm 2), 2(\pm 2, \pm 1), (\pm i, \mp 2i), (\pm 2i, \mp i).$$

Solutions and part solutions were offered by James K. Hitt, University of Wichita, Wichita, Kansas, Edith M. Warne, Minneapolis, Richard D. Donner, Syracuse, N. Y., Willis Waggoner, Syracuse, N. Y., Herbert Gales, Romulus, N. Y., C. W. Trigg, Los Angeles, Alvin Mars, Brooklyn, N. Y., A. MacNeish, Chicago, Ill., R. W. Baldwin and John R. Henderson, Upper Canada College, Toronto, Canada, M. Kirk, West Chester, Pa., Mr. J. V. Bernado, Plainville, Conn., S. E. Field, Ironwood, Michigan, James G. Go, Cebu, Cebu, P. I., Saul Ikler, Albany, N. Y., Chas. E. Jenkins, Chicago, P. H. Renton, Trafford, Pa., Leon Harter, Bowen, Ill., Will Lane, Orid, N. Y. and B. Felix John, Pittsburgh, Pa.

1615. *Proposed by Hazel C. Jones, Danville, Ill.*

In the formula for the area of a triangle, $A=\sqrt{s(s-a)(s-b)(s-c)}$, prove that $s(s-c)=(s-a)(s-b)$ if the triangle is a right triangle.

First Solution

By S. E. Field, Ironwood, Michigan

In any triangle, we have

$$\tan \tfrac{1}{2}C=\sqrt{\frac{(s-a)(s-b)}{s(s-a)}}.$$

If $C=90°$, $\tan \frac{1}{2}C=1$, and $s(s-c)=(s-a)(s-b)$.

Second Solution

By W. R. Smith, Chicago

(1) $$a^2+b^2=c^2$$

(2) $$-c^2=-a^2-b^2$$

(3) $$2ab=2ab.$$

By addition

4) $$a^2+2ab+b^2-c^2=-a^2+2ab-b^2+c^2.$$

By factoring, and dividing by 4

(5) $$\frac{(a+b+c)}{2}\,\frac{(a+b-c)}{2}=\frac{(-a+b+c)}{2}\,\frac{(a-b+c)}{2}$$ or

(6) $$s(s-c)=(s-a)(s-b)$$

Solutions were also offered by P. H. Renton, Trafford, Pa., James K. Hitt, Wichita, Kansas, John F. Wagner, Chicago, D. L. MacKay, New York, P. W. Baldwin and Malcolm K. Nelles, S. A. A. Singer, R. A. Stall, and H. J. M. Watson, Upper Canada College, Toronto, Canada, James G.

Go, Cebu, Cebu, P. I., Saul Ikler, Albany, N. Y., Cecil B. Read, Wichita, Kansas, Leon Harter Bowen, Illinois, F. Felix John, Pittsburgh, Pa., Walter R. Warne, Minneapolis, Minn., M. Kirk, West Chester, Pa., William Taylor, Port Arthur, Texas, J. V. Bernado, Plainville, Conn., C. W. Trigg, Los Angeles and also by the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

1613. *James Wishlinske, Boys' Technical H. S., Milwaukee, Wisconsin.*

1614. *Robert Pogue, Trafford Pa. H. S., and John Stark, Boys' Technical H. S., Milwaukee, Wisconsin.*

PROBLEMS FOR SOLUTION

1628. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.*

Arrange the given numbers in such manner that as n approaches infinity, the ratio of each number to the preceding also approaches infinity.

$$n^2,\ 2^n,\ n^n,\ n^{\log e^n},\ (\log n)^2,\ 2^{\log e^n},\ e^n.$$

1629. *Proposed by John N. Meighan, Hillsdale, Michigan.*

Prove that the equation

$$4n=-1+\sqrt{1+2^{y+2}}$$

is satisfied by no pair of positive integers n and y.

1630. *Proposed by George Redfield, East Varick, New York.*

If x, y, and z are real, prove that

$$\frac{x^2+y^2+z^2}{yz+zx+xy}$$

cannot have a value between 1 and -2.

1631. *Proposed by John Meyer, Lodi, New York.*

If the cubic derived from the equation

$$\frac{a}{x+a}+\frac{b}{x+b}=\frac{c}{x+c}+\frac{d}{x+d}$$

has a pair of equal roots then either one of the numbers a, b, is equal to one of the numbers c, d or

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{c}+\frac{1}{d}.$$

1632. *Proposed by Charles W. Trigg, Los Angeles City College.*

A given point P lies inside a circle of diameter AB. Find points Y on the diameter such that $PY=PQ$, where QY is perpendicular to AB and Q is a point on the circle. If P is chosen at random what is the probability that a solution exists.

1633. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.*

Given that $\tan\theta=1/5$, prove that θ is approximately $\pi/16$.

SCIENCE QUESTIONS

November, 1939

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio

Readers of School Science and Mathematics are asked to contribute: Questions, Answers, Comments, Suggestions—Whatever is new or interesting in the teaching of Science.

Your classes and yourself are invited to join the GQRA (Guild Question Raisers and Answerers). More than 290 others have already been admitted to membership by answering a question or proposing one that is published.

THE ACTIVITY OF ZINC AND COPPER

866. *Proposed by Lawrence Corey, Choteau, Montana. (Elected to the GQRA, No. 294.)*

How is it that copper is so much farther down in the electrochemical series than zinc and yet its valence is between one and two, while zinc is always two; furthermore the International atomic weight of zinc is 65.37 and the atomic weight of copper is only 63.57. These are, I believe, the two main factors which determine the activity of metals and they both seem to show that copper should be the more active.

LANDING ON THEIR FEET

867. *Proposed by Marie Litzow, Mercy High School, Milwaukee, Wis. (Elected to the GQRA, No. 295.)*

Why do cats land on their feet when they fall?

THE SCIENTIFIC METHOD

868. *Contributed by Philip B. Sharpe (GQRA, No. 262), Greenwich High School, Greenwich, New York.*

"May I draw your attention to another good scientific method question (not mine)" from the 275th High School examination in Biology of the University of the State of New York?

An experiment was performed and described as follows:

Problem: Does cabbage contain vitamin D?

Method: Ten guinea pigs were placed in a pen. Four weeks later, it was noticed that four of them had rickets. Cabbage was added to the diet of all 10 guinea pigs.

Results: The four guinea pigs with rickets recovered.

Conclusion: Cabbage is a good source of vitamin D. Make *four* specific criticisms of this experiment.

DO YOU KNOW THE ANSWERS?

(*Propose questions with quick answers for this section of* SCIENCE QUESTIONS. *Classes and teachers and outsiders are invited to contribute by question or by answer.*)

61. Which is heavier milk or cream?

62. What is "homogenized" milk?
63. Of what are "water colors" made? (Laverne Koelsch, No. 293.)
64. Can "Aurora Borealis" be produced in the laboratory?
65. The pendulum on a grandfather's clock beats seconds in Washington, D. C. Will the clock run slow or fast when taken to Florida? (From Masson's *Physics Made Easy*.)

ANSWERS TO "DO YOU KNOW THE ANSWERS"

43. Century Dictionary says!"Crawfish, crayfish—1. The common name of small fluviatile long-tailed decapod crustaceans of the genera *Astacus* and *Cambarus*."
46. Scientists are able to learn the temperature of the water 4 miles below ocean surface by sending down a self-recording thermometer with the sounding apparatus.
47. For precious stones the unit of weight is the *carat*. Century Dictionary gives eight different values. 1 carat = 1/24 ounce = 4 grains = 4 barley corns. 151.76 English carats = 1 ounce troy. 1 carat = 205 milligrams.
48. Hens have no teeth, hence the "scarcity."
49. Speedometer was slow. (See question Page 583, June, 1939, SCHOOL SCIENCE AND MATHEMATICS.)
50. At Cornell University hybrid hens that are a cross between the ordinary White Leghorns and the Araucana hen lay blue eggs.

ANSWERS TO THE "CUCKOO" BIRD TEST

865. *By Walter B. Juhnke, Teacher of Zoology, Manley High School, Chicago, Ill. (GQRA, No. 291.)*

1. The Humming Bird flies backwards as it backs away from the flower from which it has been taking nectar.
2. The Tinamu of Central America lays eggs which are highly polished and vary in color from pale pink to brilliant purple.
3. The Secretary birds of Africa are famous for killing snakes and swallowing them head first.
4. The King Bird is courageous enough to chase Crows and Hawks away from its nest.
5. Orioles are noted for their nests which swing like baskets.
6. The Duck Hawk is considered the fastest flying bird.
7. Roosters with tails over twenty feet long are now being raised in Japan.
8. The Condor, America's largest flying bird, has a wing spread of from nine to ten feet.
9. The Humming Bird fastens one leg of its young to the nest so that it can not fall out.
10. The Toucan of South America has a bill which is nearly as large as its body.
11. The Water Ouzel swims under water. The penguin is also given credit for this feat.
12. The Whip-poor-will has a big mouth with a weak bill. All around the upper lip is arranged a series of long, stiff, curving hairs, which form a sort of scoop net in which the bird catches insects.
13. The Crested Screamer of South Africa can strike tremendous blows with its wings, each of which is fitted with two hard sharp spurs.
14. The Belted King Fisher makes a nesting burrow four inches in diameter, and extending inward sometimes to a depth of twenty feet.

15. Chinese and Japanese fishermen employ the Cormorant to do their fishing for them.
16. The Owl can turn its head completely around without turning its body, so it is said to have a "rubber neck."
17. The Turkey Vulture is the bird which has the unpleasant habit of hissing and vomiting its food at its enemies.
18. The Golden Plover make a twenty-thousand mile round trip flight every year. During its migration it makes a twenty-four hundred mile non-stop ocean flight in forty-eight hours.
19. Terns of the Amazon, on hot days cool the eggs in the nest with water carried in their beaks.
20. The Penguin lays its eggs on ice and holds it on its feet while incubating it.
21. It is often said that the Pied Billed Grebe, or "Hell Diver" is able to dive out of danger before the shot reaches it. Most scientists consider the Loon to be a better diver than the Grebe.
22. After mating Mrs. Hornbill retires to her nest in a hollow tree and her mate promptly plasters up the entrance, leaving an opening only large enough to furnish her and the coming offspring with food.
23. The Cow Bird is the bird which lays her eggs in the nest of other birds.
24. The Ostrich lays eggs which average three pounds in weight.
25. The Pigeons feed their young on regurgitated milk. The young thrust their beak into the throat of the parent, and the latter pumps "pigeon milk" into their mouth.

If you succeeded in answering twenty of these questions correctly, consider yourself an Ornithologist.

NEW MEMBERS OF THE GQRA

294. Lawrence Corey, Choteau, Montana.
295. Marie Litzow, Mercy High School, Milwaukee, Wis.

BACTERIA, FUNGI, ETC., IN SOIL HAVE PART IN PREVENTING EROSION

Soil erosion prevention is not a matter of grass planting and reforestation alone. The microscopic "forests" of bacteria, fungi and other microorganisms that live in the soil also play an important role in holding it in place, it has been demonstrated in experiments by Drs. Selman A. Waksman and James P. Martin of the New Jersey Agricultural Experiment Station.

Microbes can bind the soil in several different ways, they explain in a recent issue of *Science*. Fungi and some bacteria form subterranean networks of thread-like growth, that have considerable mechanical holding power. Bacteria secrete slimy substances that glue soil particles together. All the organisms of decay act on dead leaves and other plant parts to change them into humus, which has a recognized high value in soil conservation.

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

PROGRAM

Thirty-Ninth Convention Central Association of Science and Mathematics Teachers
November 24 and 25, 1939
Morrison Hotel—Chicago

GENERAL PROGRAM

Friday Morning, November 24, 9:45 A.M.

Terrace Casino, Lower Lobby

9:45–10:00 *Reports of National Committees.*
National Science Committee—Harold Metcalf.
National Commission on Co-operative Curriculum Planning—Harold G. McMullen.

10:00–10:40 "Adventures at Low Temperatures."
Dr. B. J. Luyet, Professor of Biology, St. Louis University, St. Louis, Missouri.

10:40–11:20 "Science, Ethics, and War."
Dr. E. R. Hedrick, Vice-President and Provost, University of California at Los Angeles, Los Angeles, California.

11:20–12:00 "History without Generals."
Dr. C. C. Furnas, Associate Professor of Chemical Engineering, Yale University, New Haven, Connecticut.

Friday Evening, November 24, 6:00 P.M.

Terrace Casino and Lower Lobby—Reception and Annual Dinner

6:00–6:30 *Reception.*

6:30–9:30 *Dinner and Program*—Tickets $2.00, including tip.
Make reservations with Miss Mildred Fahy, Peirce School, Chicago, Illinois. Purchase tickets at registration desk.
Address: "Chemistry through the Microscope."
Dr. H. S. Booth, Professor of Chemistry, Western Reserve University, Cleveland, Ohio.

Saturday Morning, November 25

8:00–9:00 *Business Meeting*, Mural Room.

9:00–10:00 *General Meeting*, Terrace Casino.
"Coming of Man."
Dr. Fay-Cooper Cole, Chairman of Department of Anthropology, University of Chicago, Chicago, Illinois.

10:00–12:00 *Four Group Meetings.*

Elementary School Group, Mural Room, First Floor.

Veva McAtee, presiding.

10:00–11:00 "Information Please."
Authorities: Mary Melrose, *Chairman*, Supervisor of Elementary Science, Cleveland, Ohio.
Dr. S. R. Powers, Teachers College, Columbia University, New York City.
Dr. W. C. Croxton, State Teachers College, St. Cloud, Minnesota.
Ira C. Davis, University High School, Madison, Wisconsin.
Dr. Rose Lammel, Ohio State University, Columbus, Ohio.

11:00–12:00 "Important Questions Concerning the Teaching of Arithmetic."

Panel: Dr. Charles A. Stone, *Chairman*, Professor of Education, De Paul University, Chicago, Illinois.
Dr. J. T. Johnson, Head of the Department of Mathematics, Chicago Teachers College, Chicago, Illinois.
Butler Laughlin, Principal, Lindbloom High School, Chicago, Illinois.
Harry O. Gillet, Principal, University of Chicago Elementary School, Chicago, Illinois.

Junior High School Group, Roosevelt Room, Second Floor.

F. R. Bemisderfer, presiding.
10:00–10:40 "Trends in Junior High School Mathematics."
Dr. Raleigh Schorling, Professor of Education, University of Michigan, Ann Arbor, Michigan.
10:40–11:20 "Catching Vitamins on Fish Hooks."
Dr. Frank Kirby, Director of Education, Abbott Laboratories, North Chicago, Illinois.
11:20–12:00 Spoiling the Scientific Attitude of Junior High School Students."
Dr. George Skewes, Head of Department of Education, State Teachers College, Mayville, North Dakota.

Senior High School Group, Casino, Lower Lobby.

Ada Louise Weckel, presiding.
10:00–10:40 "Two-year Physical Science Courses in University of Chicago."
Dr. Selby Skinner, Assistant Professor of Physical Sciences, University of Chicago, Chicago, Illinois.
10:40–11:20 "Social Arithmetic in Senior High School."
W. O. Smith, South High School Cleveland, Ohio.
11:20–12:00 "The Human Side of Nature" (Illustrated).
Sam Campbell, Three Lakes, Wisconsin.

Junior College Group, Embassy Room, Mezzanine Floor.

Jerome Isenbarger, presiding.
10:00–10:40 "Maintaining the Scientific Attitude in Science Survey Courses."
Dr. George Skewes, Head of Department of Education, State Teachers College, Mayville, North Dakota.
10:40–11:20 "Scientific Knowledge and Human Action."
Dr. Joseph Schwab, Instructor in Biology, University of Chicago, Chicago, Illinois.
11:20–12:00 "Modern Views on the Structure of the Universe."
Dr. Frank Kelley Edmondson, Instructor in Astronomy, Indiana University, Bloomington, Indiana.

Section Meetings

Biology

Friday, November 24, 1:00 P.M.
Room 429, Fourth Floor

1:00–2:00 *Program by Exhibitors.*
2:00–2:45 "Biological Organization and Cell Theory."
Dr. B. J. Luyet, Professor of Biology, St. Louis University, St. Louis, Missouri.
2:45–3:05 "The Biology Club as a Chapter of the Junior Academy."

Katherine Pfeifer, Soldan High School, St. Louis, Missouri.

3:05–3:10 *Election of Officers.*

3:10–4:00 "The Relation of the Endocrine Glands to Growth and Learning."

Dr. A. C. Ivy, Professor of Physiology, Northwestern University Medical School, Evanston, Illinois.

4:00–4:55 *Program by Exhibitors.*

Chemistry

Friday, November 24, 1:00 P.M.

Embassy Room, Mezzanine Floor

1:00–2:00 *Exhibit of Student Work.*

American Institute, State Junior Academies of Sciences, and Cooperative Science Clubs.

2:00–2:25 "Methods and Importance of pH and Acidity Measurements."

Dr. Malcolm Dole, Associate Professor of Chemistry, Northwestern University, Evanston, Illinois.

2:25–2:50 "The Contributions of Chemistry in the Field of Hormones to Health Control."

Dr. Fred C. Koch, Chairman of Department of Biochemistry University of Chicago, Chicago, Illinois.

2:50–2:55 *Election of Officers.*

2:55–3:02 "American Institute of the City of New York Science Club Program."

Dr. H. H. Sheldon, Managing Trustee, American Institute, New York City.

3:02–3:09 "Cooperative Science Clubs."

Dr. Rosalie M. Parr, University of Illinois, Urbana, Illinois.

3:09–4:00 *Panel Discussion*—Future of the Specialized Sciences in the High School.

Dr. J. O. Frank, Chairman of Chemistry Department, State Teachers College, Oshkosh, Wisconsin.

Theodore Kelsey, Chemistry Department, Cleveland High School. St. Louis, Missouri.

Martin V. McGill, Chairman, Division of Chemical Education, Lorain, Ohio.

Dr. Victor H. Noll, Acting Head of Department of Education, Michigan State College, East Lansing, Michigan.

4:00–4:30 *Program by Exhibitors.*

Elementary Science

Friday, November 24, 1:15 P.M.

Mural Room, First Floor

1:15–2:00 *Program by Exhibitors.*

2:00–2:15 *Election of Officers.*

2:15–2:45 "Development of a Unit of Work in Elementary Science."

Gladys Forler, Director of Science, Atwood School, Shorewood, Wisconsin.

2:45–3:30 "Does Elementary Science Teach Children to Think?"

Gerald Craig, Associate Professor of Natural Sciences, Columbia University, New York City.

3:30–4:00 "How Shall We Correlate Science with the other Subjects?"

Rose Lammel, Assistant Professor of Natural Science, Ohio State University, Columbus, Ohio.
4:00–4:30 *Program by Exhibitors.*

General Science

Friday, November 24, 2:00 P.M.
Room 329, Third Floor

2:00–2:30 "Science for Leisure Time as Developed through Work in the Junior Academy of Science."
Dean Stroud, Amos Hiatt Junior High School, Des Moines, Iowa.
2:30–3:00 "The Flying Telephone as Used in Aeronautics."
Willard J. Combs, Director of Aeronautics, North High School, Des Moines, Iowa.
3:00–3:05 *Election of Officers.*
3:05–4:00 "The Content of Junior High School Science as Reflected in Current Textbooks and State Courses of Study."
Donald D. Pettit, Staff Lecturer, University High School, Iowa City, Iowa.
4:00–4:30 *Program by Exhibitors.*

Geography

Friday, November 24, 1:15 P.M.
Walnut Room, Second Floor

1:15–2:00 *Program by Exhibitors.*
2:00–2:15 *Election of Officers.*
2:15–2:45 "Some Problems Confronting the Geography Teacher."
Dr. Frederick R. Bransom, Head of Department of Social Science, Chicago Teachers College, Chicago, Illinois.
2:45–3:15 "Relation between High School and College Geography,"
Edith Glatfelter, Professor of Geography, Harris Teachers College, St. Louis, Missouri.
3:15–4:00 "The Geographer, the Land, and the People."
Dr. Helen Strong, Educational Relations, Soil Conservation Bureau, Washington, D.C.
4:00–4:30 *Program by Exhibitors.*

Mathematics

Friday, November 24, 2:00 P.M.
Casino, Lower Lobby

2:00–2:15 *Election of Officers.*
2:15–2:45 "Functional Thinking."
Dr. E. R. Hedrick, Vice-President and Provost, University of California at Los Angeles, Los Angeles, California.
2:45–3:15 "The Contribution of Mathematics to General Education."
Professor Raleigh Schorling, Head of the Department of Mathematics in University High School, Ann Arbor, Michigan.
3:15–3:45 "Issues Raised by Recent Reports on the Mathematics Curriculum."
Dr. Maurice Hartung, Associate Director, Progressive Education Association, University of Chicago, Chicago, Illinois.
3:45–4:00 *Discussion.*
4:00–4:30 *Program by Exhibitors*

Physics

Friday, November 24, 2:00 P.M.

Roosevelt Room, Second Floor

2:00–2:30 "Physics in General Education."
Dr. Louis M. Heil, Associate Professor of Education, University of Chicago, Chicago, Illinois.

2:30–3:00 "Physics as a Career."
Dr. E. U. Condon, Associate Director, Westinghouse Research Laboratories, East Pittsburg, Pennsylvania.

3:00–3:30 "Forward Looking Steps in the Teaching of Physics."
Dr. S. R. Powers, Professor of Natural Sciences, Columbia University, New York City.

3:30–3:45 *Election of Officers.*

3:45–4:00 "The Selection of Apparatus for High School Physics."
Philip Tapley, Tilden High School, Chicago, Illinois.

4:00–4:30 *Program by Exhibitors.*

Extra-Convention Activities

THURSDAY, NOVEMBER 23: A limited number of tickets for the Thursday evening performance in the main studio of radio station W-G-N has been reserved by the association. These tickets will be reserved for members, without cost, upon application to Harold Metcalf, Secretary, by Tuesday, November 21.

SATURDAY, NOVEMBER 25: Trip through Museum of Science and Industry. Meet inside the main entrance of the Museum at 2:00 P.M.

PROGRAM BY EXHIBITORS

All Demonstrations and Lectures to be on Friday, November 24

GENERAL

Title: *Editors as Goats*
Time: 9:15–9:45 Place: Casino
Speaker: Dr. Hanor A. Webb
Sponsor: American Education Press, Inc.
Title: *The Scientific Exploration of the Antarctic by the Snow Cruiser*
Time: 12:00–12:30 Place: Casino
Speaker: Harold Vagtborg
Sponsor: W. M. Welch Manufacturing Company

BIOLOGY

Title: *Materials and Methods Used in the Manufacture of Biological Models*
Time: 9:15–9:45 Place: Mural Room
Speaker: Edgar A. Baird
Sponsor: Chicago Apparatus Company
Title: *Use of Charts in Biology*
Time: 1:00–1:30 Place: Room 429
Speaker: To be announced
Sponsor: A. J. Nystrom and Company
Title: *The Study of Ants, Bees, and Wasps in Natural Science Courses*
Time: 1:30–2:00 Place: Room 429
Speaker: A. S. Windsor
Sponsor: General Biological Supply House
Title: *The Classification and Characteristics of Animals*
Time: 4:00–4:25 Place: Room 429
Speaker: To be announced

Sponsor: Denoyer-Geppert Company
Title: *Demonstration of Kodachrome Projector*
Time: 4:25–4:55 Place: Room 429
Speaker: E. V. Finnegan
Sponsor: Spencer Lens Company

CHEMISTRY

Title: *How Laboratory Glassware is Made*
Time: 4:00–4:30 Place: Embassy Room
Speaker: D. K. York
Sponsor: Central Scientific Company

ELEMENTARY SCIENCE

Title: *Demonstration of Effective Elementary Science Teaching*
Time: 1:15–1:45 Place: Mural Room
Speaker: Miss Tillie R. Schlumberger
Sponsor: Scott, Foresman, and Company
Title: Film: *Marshland Mysteries*
Time: 4:00–4:30 Place: Mural Room
Speaker: Robert H. Unseld
Sponsor: Bell and Howell Company

GENERAL SCIENCE

Title: *The Use of Lantern Slides in Teaching Science*
Time: 4:00–4:30 Place: Room 329
Speaker: R. C. Hamilton
Sponsor: Keystone View Company

GEOGRAPHY

Title: *The Presence of Maps in Geography Instruction*
Time: 1:15–1:45 Place: Walnut Room
Speaker: To be announced
Sponsor: A. J. Nystrom and Company
Title: *Classroom Enrichment*
Time: 4:00–4:30 Place: Walnut Room
Speaker: Miss Esther M. Bjoland
Sponsor: Society for Visual Education, Inc.

MATHEMATICS

Title: *Practical Mathematics*
Time: 4:00–4:30 Place: Casino
Speaker: To be announced
Sponsor: Lafayette Instruments Inc.

PHYSICS

Title: *The Magnetic Spectrum*
Time: 4:00–4:30 Place: Roosevelt Room
Speaker: Charles Kruse
Sponsor: Central Scientific Company

BOOKS AND PAMPHLETS RECEIVED

Modern Physics, by Charles E. Dull, Head of Science Department, West Side High School, and Supervisor of Science for the Junior and Senior High Schools, Newark, New Jersey. Revised. Cloth. Pages x + 587 + xxv. 15 × 23.5 cm. 1939. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.80.

Applied Chemistry, by Sherman R. Wilson, Head of the Exact Science Department, Northwestern High School, Detroit, Michigan, and Mary R. Mullins, Chairman of Physical Science, New Utrecht High School, Brooklyn, New York. Cloth. Pages xiv + 530. 13.5 × 19.5 cm. 1939. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.72.

Introduction to Geometry, by A. W. Siddons, Late Fellow of Jesus College, Cambridge; late Senior Mathematical Master at Harrow School, and K. S. Snell, Late Scholar of Trinity College, Cambridge; Senior Mathematical Master at Harrow School. Cloth. Pages vi + 167. 13 × 19 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 80 cents.

Applied Mathematics, by James F. Johnson, Late Principal, Essex County Boys' Vocational School, Newark, New Jersey. Cloth. Pages vii + 434. 13.5 × 21 cm. 1939. Bruce Publishing Company, 540 North Milwaukee Street, Milwaukee, Wis. Price $1.40.

Descriptive Geometry, by James T. Larkins, Jr., Pennsylvania State College. Cloth. Pages viii + 317. 15 × 23 cm. 1939. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $2.50.

Selective Experiments in General Chemistry, by Alexander Silverman, Head of the Department of Chemistry, University of Pittsburgh, and Abraham L. Robinson, Assistent Professor of Chemistry, University of Pittsburgh. Cloth. Pages xi + 310. 21 × 26.5 cm. 1939. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.50.

Mechanics, by L. Raymond Smith, Instructor in Industrial Physics, William L. Dickinson High School, Jersey City, N. J. Revised Edition. Cloth. Pages xiv + 299. 12 × 19 cm. 1939. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $1.75.

Plane Trigonometry with Tables, by Miles A. Keasey, Head of the Department of Mathematics, Drexel Institute Evening School, Philadelphia and Department of Mathematics, South Philadelphia High School for Boys; G. Alfred Kline, Department of Mathematics, South Philadelphia High School for Boys, and Department of Mathematics, Drexel Institute Evening School, Philadelphia; and D. Allison McIlhatten, Head of the Department of Mathematics, Girard College, Philadelphia and Department of Mathematics, Drexel Institute Evening School, Philadelphia. Second Edition. Cloth. Pages ix + 144. 15.5 × 23.5 cm. 1939. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $1.28.

Thoreau, Reporter of the Universe, by Bertha Stevens. Cloth. Pages xiv + 299. 13.5 × 20.5 cm. 1939. The John Day Company, 40 East 49th Street, New York, N. Y. Price $2.50.

A Second Book of Plant Names, by Willard N. Clute. Cloth. Pages xi + 164, 14 × 21 cm. 1939. Willard N. Clute and Company, 5257 Hinesley Avenue, Indianapolis, Ind. Price $3.00.

Outline of Physiology, by William R. Amberson, Professor of Physiology, University of Maryland, and Dietrich C. Smith, Associate Professor of Physiology, University of Maryland. Cloth. Pages vii + 412. 17.5 × 25.5 cm. 1939. F. S. Crofts and Company, 41 Union Square, West, New York, N. Y. Price $4.00.

Matter, Motion and Electricity, by Henry De Wolf Smyth, Chairman, Department of Physics, Princeton University, and Charles Wilbur Ufford,

Professor of Physics, Allegheny College. Cloth. Pages xiii + 648. 15 × 23 cm. 1939. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York, N. Y. Price $3.75.

Science Problems, Book Three, by Wilbur L. Beauchamp, The University of Chicago, John C. Mayfield, The University High School, Chicago, and Joe Young West, Maryland State Teachers College, Towson. Cloth. Pages x+756. 14 × 21 cm. 1939. Scott, Foresman and Company, 623 South Wabash Avenue, Chicago, Ill. Price $1.68.

Household Physics, Third Edition, by Walter G. Whitman, State Teachers College, Salem, Mass. Cloth. Pages vi + 436. 14.5 × 23 cm. 1939. John Wiley & Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.00.

Teaching Mathematics in the Secondary Schools, by J. H. Minnick, Ph.D., University of Pennsylvania. Cloth. Pages xiv + 336. 13.5 × 20.5 cm. 1939. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.00.

The Relative Difficulty of Certain Topics in Mathematics for Slow-Moving Ninth Grade Pupils, by Vergil S. Mallory, Ph.D., Teachers College, Columbia University. Cloth. Pages x+179. 14.5 × 23 cm. 1939. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $2.10.

Understanding Our Environment, by Franklin B. Carroll, Frankford High School, Philadelphia. Cloth. Pages x + 438. 13 × 21 cm. 1939. The John C. Winston Company, Philadelphia, Pa. Price $1.48.

Understanding Our World, by Franklin B. Carroll, Frankford High School, Philadelphia. Cloth. Pages xi + 554. 13 × 21 cm. 1939. The John C. Winston Company, Philadelphia, Pa. Price $1.56.

Understanding the Universe, by Franklin B. Carroll, Frankford High School, Philadelphia, Frank A. Rexford, Museum of the City of New York and Henry T. Weed, Girls' Commercial High School, Brooklyn. Cloth. Pages xx+712. 13 × 21 cm. 1939. The John C. Winston Company, Philadelphia, Pa. Price $1.68.

Calculations of Quantitative Analysis, by Carl J. Engelder, Ph.D., Professor of Analytical Chemistry, University of Pittsburgh. Cloth. Pages viii+174. 14.5 × 23 cm. 1939. John Wiley & Sons, Inc. 440 Fourth Avenue, New York, N. Y. Price $2.00.

Mathematics in Action, Book Two, by Walter W. Hart, Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin and Lora D. Jahn, Vice-Principal Junior High School Number One, Trenton, N. J. Cloth. Pages ix + 374. 1939. D. C. Heath & Company, 285 Columbus Avenue, Boston, Mass. Price $.96.

The Secondary School, by Charles Watters Odell, Ph.D., Associate Professor of Education, University of Illinois. Cloth. Pages viii + 606. 13 × 22 cm. 1939. The Garrard Press, Champaign, Ill. Price $3.00.

Science in Our Lives, Teacher's Manual, by Benjamin C. Gruenberg and Samuel P. Unzicker, Paper. Pages iii+171. 13×19 cm. 1939. World Book Company, Yonkers on Hudson, N. Y. Price $.80.

Heath Workbook in General Mathematics. Book One and Book Two. Paper. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $.24 each.

Laboratory Exercises in Physiography, by Gustav L. Fletcher, James Monroe High School, New York City. Paper. Pages 10+162. 20×27 cm. D. C. Heath and Company, Yonkers on-Hudson, N. Y. Price $.68.

Electrochemistry, A Guide for Use with the Instructional Sound Film "Electrochemistry," prepared by Melvin Brodshaug, Erpi Classroom Films Inc., and W. Lyle Brewer, Advanced School of Education, Teachers College, Columbia University, in Collaboration with Hermann I. Schlesinger and Warren C. Johnson, The University of Chicago, Paper. Pages iv+26. 13.5×20 cm. 1939. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price 15 cents.

Colloids, A Guide for Use with the Instructional Sound Film "Colloids," prepared by Melvin Brodshaug, Erpi Classroom Films Inc., and James A. Fraser, Advanced School of Education, Teachers College, Columbia University in Collaboration with Hermann I. Schlesinger and Warren C. Johnson, The University of Chicago. Paper. Pages iv+29. 13.5×20 cm. 1939. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price 15 cents.

A Working Philosophy of Education for Pennsylvania. Bulletin 14. Lester K. Ade, Superintendent of Public Instruction. 44 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Instruction, Harrisburg, Pa.

Special Opportunities of Small Rural Schools. Bulletin 230. Lester K. Ade, Superintendent of Public Instruction. 97 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Instruction, Harrisburg, Pa.

Addenda to Rara Arithmetica, by David Eugene Smith. Paper. Pages x+52. 15×23.5 cm. 1939. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $2.00.

A Working Philosophy in the Field of Teacher Education. Bulletin 157. Lester K. Ade, Superintendent of Public Instruction. 20 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Instruction, Harrisburg, Pa.

Radio in Education, compiled and written by the Federal Writers' Project Works Progress Administration Commonwealth of Pennsylvania. Paper. 47 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Instruction, Harrisburg, Pa.

Technical and Business Institute Education. Bulletin 337. Lester K. Ade, Superintendent of Public Instruction. 48 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Instruction, Harrisburg, Pa.

U. S. Community Improvement Appraisal, A Report on the Work Program of the Works Progress Administration, by the National Appraisal Committee. Paper. 62 pages. 20×26 cm. 1939. Works Progress Administration, Washington, D. C.

Das Aufbauprinzip der Technik, by Dr. P. Wessel. Paper. 39 pages. 14×22 cm. 1937. Ernst Reinhardt, München, Germany. Price 1.50 Marks.

Practical Contributions on Science in the Grades Interest, Activities, Experience and Suggestions, by Dorothy V. Phipps, David W. Russell, Mildred Fahy, Gladys Forler, Meridel Underwood, and Marjorie Prat Paper. 39 pages. 15×23 cm. 1939. SCHOOL SCIENCE AND MATHEMATICS,

W. F. Roecker, 3319 North 14th Street, Milwaukee, Wisconsin. Price 40 cents or 30 cents in lots of 25.

Quantitative Aspects of Experiencing in the Elementary School. Bulletin 360. Lester K. Ade, Superintendent of Public Instruction. Pages vii+221. 14×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Meeting the Needs of the Mentally Retarded. Bulletin No. 420. Lester K. Ade, Superintendent of Public Instruction. Pages ix+168. 14×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Institutions of Higher Learning in Relation to a State Program of Teacher Education. Bulletin 156. Lester K. Ade, Superintendent of Public Instruction. 29 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Home Classes for Foreign-Born Mothers. Bulletin 295. Lester K. Ade, Superintendent of Public Instruction. 77 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Creative Hands and Purposeful Activities in the Elementary School. Bulletin 333. Lester K. Ade, Superintendent of Public Instruction. 61 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Official Forms in Use (A Bibliography). Bulletin 8. Lester K. Ade, Superintendent of Public Instruction. 25 pages. 15×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

The Meaning of Mathematics, by Cassius Jackson Keyser. Second Edition. Paper. 14 pages. 13×19 cm. Scripta Mathematica, Amsterdam Avenue and 186th Street, New York, N. Y. Price 20 cents.

Thomas Jefferson and Mathematics, by David Eugene Smith. Second Edition. Paper. 16 pages. 13×19 cm. Scripta Mathematica, Amsterdam Avenue and 186th Street, New York, N. Y. Price 25 cents.

Useful Mathematics Workbook, by Mary A. Potter, Supervisor of Mathematics, Racine, Wisconsin. Paper. 112 pages. 18.5×19 cm. 1939. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price 48 cents.

BOOK REVIEWS

Fundamental Electronics and Vacuum Tubes, by Arthur Lemuel Albert, Professor of Communication Engineering, Oregon State College. Cloth. Pages ix+422. 14×23 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.50.

A course in electronics and vacuum tubes is now a standard course in all engineering schools and in many universities. With the introduction of this course a number of high grade textbooks have appeared, but development of the subject is so rapid that texts cannot keep pace with the progress. This text brings the record up to the date of publication and is a worthy rival to any book in the field. Well selected subject matter, able presentation, good lists of references to books and journal articles, and sug-

gested assignments are the outstanding characteristics. It consists of fourteen chapters covering four major topics: fundamental principles of electronics, principles of vacuum tubes, vacuum tube circuits, cathode-ray and photoelectric tubes and their applications. No book designed for class work can cover these subjects comprehensively, and many topics of interest to the specialist are not discussed in this one; but all the basic principles are thoroughly treated in language that can be comprehended by all students in electrical fields. The references are sufficient to start specialization in any branch of electronics. Although the book is best adapted for students in communication, those preparing for industrial applications will find it adequate. The treatment is strongly descriptive but analysis is not shunned.

G. W. W.

A Picture Dictionary for Children, by Garnette Watters, Director of the Language Department of the Public Schools, Hamtramch, Michigan, and S. A. Courtis, Professor of Education, University of Michigan. Cardboard. 478 pages. 21 × 28 cm. 1939. Grosset and Dunlap, Inc., 1107 Broadway at 24th Street, New York, N. Y. Price $1.00.

A dictionary for children just learning to read is something new. Over two thousand scientifically selected words are included. Variations such as plurals, principal parts, comparatives and superlatives, add nearly three thousand more word forms. The basic words are presented in both print and script. Pictures are used to illustrate twelve hundred words. Sentences and synonyms make clear the meaning and use. The usual intricate dictionary mechanics—punctuation, derivation, classification, etc.—is omitted. Instead of the formal study demanded of the mature pupil the beginner learns to recognize words both in print and script, acquires their correct uses, learns spelling, becomes familiar with the alphabet and an index, and forms the dictionary habit, all while being entertained. For children in school or at home this book is worth many times its cost.

G. W. W.

Teaching Nutrition in Biology Classes. An Experimental Investigation Of High School Biology Pupils in Their Study of the Relation of Food to Physical Well Being, by N. Eldred Bingham Ph.D. of Teachers College Columbia University, Contributions to Education no. 772. A Lincoln School Research Study. Cloth. 15 ×23 cm. pages viii +117, 46 tables, charts and graphs. Bureau of Publications, Teachers College, Columbia University, New York. 1939. Price $1.85.

Here is a work which should delight the advocate of progressive education. A volume on one unit in biology viz; nutrition. A survey quoted by the author tends to show that this matter of a proper understanding of nutrition in relation to bodily health is poorly presented in most biology texts of high school grade. The traditional method of presenting this matter of nutrition is not objective enough according to this author and as result this work is presented. The book outlines in exhaustive detail a study of this topic which should result in the ability of the students who follow this course to evaluate and improve an already fairly adequate diet so that better growth for the young, better development, a higher level of activity for the adult and an expected extended average increase in adult longevity. The unit requires 30 class periods to complete. What the length of the periods were to be is not mentioned in the work. Small animals respiration apparatus and calorimeters are extensively used in this unit.

A. G. ZANDER

Our Natural Resources and Their Conservation. Edited by A. E. Parkins, George Peabody College for Teachers and J. R. Whitaker, University of Wisconsin. Contributors; Wallace W. Atwood, Clark University. O. E. Baker, Senior Agricultural Economist U.S.D.A. Nels Bengston, Nebraska, U. H. H. Bennett, Soil Conservation Service, U.S.D.A. Ralph Brown, Minnesota U. Robert M. Brown, Rhode Island College of Education. Loyal Durand, Jr., Wisconsin U. W. H. Haas, Northwestern U. H. C. Hanson, North Dakota Agr. Exp. Station. Ellsworth Huntington, Yale U. H. H. Martin, Washington U. George J. Miller, State Teachers College, Mankato, Minn. Edward C. Prophet, Michigan State College. George T. Renner, Teachers College Columbia U. V. E. Shellford, Ill. U. Guy-Harold Smith, Ohio State U. J. Russell Smith, Columbia U. Helen M. Strong, Soil Conservation Service U.S.D.A. S. S. Visher, Indiana U. Frank Williams, Pennsylvania U. Louis A. Wolfanger, Conservation Institute Michigan State College. Cloth. Pages xiv and 647. 15.5 × 23 cm. 137 figures including tables. John Wiley and Sons Inc. New York. 1939. $4.00. 2nd edition.

This is probably the most authoritative book in its field. The joint authorship method gives this book its authoritative place. All original material from all the fields covered by conservation. These men are specialists in their particular subjects. The book is divided into 10 parts of 24 chapters. The fields covered are: I—Conservation Movement in America. II—The Public Domain, Soils, Erosion, Arid and Semi-arid Lands, Grasslands, Reclamation, Agriculture. III—Forestry. IV—Water, Waterways, Waterpower, Floods. V—Minerals and Fuel Resources. VI—Conservation in Relation to Industry. VII—Wildlife and Fisheries. VIII—Recreational Resources. IX—Conservation of Man. X—Planning, State, Local, Federal Reference Maps, Agricultural Data and an up-to-date bibliography. We consider it excellent for teaching and reference purposes.

A. G. ZANDER

Farm Management, by Robert R. Hudelson, College of Agriculture, University of Ill. Urbana, Ill. Cloth. Pages x and 396. 15 × 21.5 cm. 75 figures and tables. Macmillan Co., New York, 1939. $1.80.

A text for use in agriculture education. This book is suitable for both high school and college grade. In order to understand the value of this book the background of the author is given. He has managed professionally various farms of different sizes and kinds in the corn belt and adjoining states. He has spent some years in directing the extension work in farm management for one of the corn belt states. The book is divided into three parts: I—Organizing the Farm Business. II—Operating the Farm Business. III—Farm Finance and Farm Accounts. These parts are divided into 21 chapters. Besides those for whom the book appears to have been specifically written, anyone not engaged in agriculture but interested in it could read this book with profit. The section devoted to farm finance and farm accounts is very illuminating. A fine item in this section deals with the matter of tenancy and ownership and all the fine points concerning this matter of renting or owning.

A. G. ZANDER

A Second Book of Plant Names, by Willard Clute. 15 × 21 cm. pages x + 164. No illustrations. Willard Clute and Co. Indianapolis, Ind. 1939. $3.00.

To his 15 or 16 other interesting books on botanical subjects Mr. Clute adds this one on nomenclature. It is written in a style which should appeal

to the nature lover. The book traces the origin of the common names of many plants especially those about which we hear and see the most. There are 16 chapters. An exhaustive index follows.

A. G. ZANDER

Handbook of Chemistry and Physics, A Ready-Reference Book of Chemical and Physical Data, by Editor in Chief, Charles D. Hodgman, Associate Professor of Physics at Case School of Applied Science. Twenty-third Edition. Cloth. Pages xviii+2221. 11.5×18 cm. 1939. The Chemical Rubber Company, 1900 W. 112th Street, Cleveland, Ohio. Price De luxe Edition $6.00 in United States and Canada, Six Dollars and Fifty Cents elsewhere.

Each new edition of the *Handbook* is more comprehensive than its predecessor. The 23rd edition contains 152 pages more than the 22nd edition and has a larger page size. The five major divisions are composed of data contributed by 165 collaborators, each an authority in his field. Whether one is working in mathematics or physics or chemistry the *Handbook* is one of his most useful tools, a great time-saver, a reliable source of information. Definitions, chemical formulas, physical laws, properties of elements and compounds, all the commonly used mathematical tables, conversion tables, characteristics of thermionic tubes, etc., etc. are provided in one convenient volume. No student of physical science can afford to be without this book.

G. W. W.

Radio Trouble-Shooter's Handbook, by Alfred A. Ghirardi, author of "The Radio Physics Course," "Modern Radio Servicing," etc. Cloth. Pages x+518. 21.5×28 cm. 1939. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $3.00.

As the title indicates this book is compiled in the form of a handbook for those interested in the servicing of practical electronic devices. Case histories, common receiver troubles, manufacturers' specifications, wiring diagrams of automobiles, sound and intercommunicator systems, test equipment, coil and tube data, and a host of other information useful to the shop man and radio engineer are included. Those familiar with Alfred Ghirardi's *Radio Physics* and *Modern Radio Servicing* will find this book a practical supplement. The binding and paper are of high quality capable of withstanding hard usage. The diagrams are clearly labeled and the tables well defined. The many cross references are an added convenience.

L. C. WARNER, R.C.A. Institutes, Chicago

The Concepts of the Calculus, A Critical and Historical Discussion of the Derivative and the Integral, by Carl B. Boyer. Pages vii+346. Cloth. Columbia University Press, Morningside Heights, New York. 1939 Price $3.75.

In the common tendency to ascribe the invention of the calculus to Newton and Leibniz perhaps we have tended to forget not only the work of their predecessors but also the more rigorous formulations of their followers. This work emphasizes these phases, tracing in considerable detail the development of the fundamental concepts of the derivative and the integral from the time of the Egyptians and Babylonians to the present era. It is clearly indicated in what manner the work of various individuals contributed to the development of calculus as we know it now. In particular the author points out that while there is need for logical foundations and clear definitions of the concepts involved, the banishment of all sug-

gestive views would be a serious mistake. The author portrays the growing tendency throughout the years to formalize and arithmetize the subject, rather than have it depend upon geometry or naturalistic description. Likewise it is emphasized how slowly the concepts of ultimate ratios and infinitesimals have given way to the present ideas of limits.

This book should be read by all teachers of analysis; if it does nothing else it will raise the question of the degree of rigor in the ordinary beginning text or course; certainly it emphasizes some mistakes in the thinking of eminent mathematicians which may be pitfalls for the student. Even the teacher of elementary algebra would find many valuable passages; for example, in many places he may be able to help clarify the thinking of students who are confused regarding the possibility of division by zero.

CECIL B. READ, *University of Wichita*

College Algebra, by H. L. Rietz, University of Iowa, and A. R. Crathorne, University of Illinois. Fourth Edition. Cloth. Pages xv+298. 14×21.5 cm. 1939. Henry Holt and Company, New York. Price $1.85.

Comparison with the third edition shows several changes in the order in which topics are presented. Many of the chapters are, as in the former edition, essentially independent units, and the order of presentation is largely at the disposal of the individual instructor. The material on certain topics has been expanded, usually, it would seem, for the purpose of simplifying the presentation. This is especially apparent in the review of pre-college algebra, in the work on systems of equations, and in the chapter on theory of equations.

While the authors state that the problems have been very completely changed, a comparison with the third edition shows a large number of identical exercises, particularly in the case of the "worded" problem. Since a large number of the changes which have been made are merely changes in the numerical constants, it seems unfortunate that similar changes were not made throughout the book. Collections of solved examples often found in the fraternity house will still be of considerable value for the fourth edition.

The typography is excellent, and, in the use of italics and bold-faced type, seems to be much more consistent than was the case in the previous edition. Even with a change in the size of the page and color of binding, the text is at once recognized as an old friend.

CECIL B. READ, *University of Wichita*

Synthetic Projective Geometry, by R. G. Sanger, Ph.D., Instructor in Mathematics, University of Chicago. Cloth. Pages ix+175. 14.5×21 cm. 1939. McGraw-Hill Book Company, Inc., New York, N. Y. Price $2.00.

As in many texts intended for a first course in projective geometry, the author points out that no attempt has been made to develop the subject with extreme rigor. Special cases and technicalities have been avoided, assumptions have been made without proof, and extreme detail is avoided. But, different from many books, the preface is not the only place where such a statement is found (too often the student never reads the preface). Throughout the text one finds clear statements of the assumptions involved, the need for proof of such assumptions (as for example in the case of the principle of duality), and in many cases the possibility of other methods of treatment than the one used in the text.

The primary emphasis is upon projective geometry in the plane; a brief chapter of twelve pages is devoted to space geometry. After six chapters devoted to important phases of projective geometry such as are

customarily treated in a first course, the author devotes one of the longest chapters in the book to the subject "Metric Properties of Projective Figures." This chapter presents in an excellent manner the relationship between projective geometry and the metric geometry which the student has heretofore encountered. It should be of especial value to the teacher of Euclidean geometry and it would also help the teacher of analytic geometry answer some of the questions raised by the college freshman who is trying to imagine what happens when a curve "goes out to infinity."

The last chapter is devoted to a brief historical sketch of the development of projective geometry. The author makes the frank statement that the subject is out of style. His feeling is perhaps reflected at other places, as for example when he says that certain constructions have a "semblance of practicability."

CECIL B. READ, *University of Wichita*

College Algebra, Revised Edition, by Joseph B. Rosenbach, Professor of Mathematics and Edwin A. Whitman, Associate Professor of Mathematics, The Carnegie Institute of Technology. Cloth. Pages x+431 +xxxviii. 14×20.5 cm. 1939. Ginn and Company, Boston. Price $2.25.

Although the content and arrangement of the material is that of the traditional college algebra text many of the minor details make this text appear to be decidedly above the average. Interesting historical notes appear frequently throughout the text. "Warnings" which point out pitfalls into which the beginning student may leap show an especially careful analysis of frequently occurring errors. The forms of solution shown in the illustrative examples seem to give a very clear idea of the process of analysing and solving a problem; in the case of certain logarithmic solutions it would seem, however, that while the form suggested helps to teach the process involved, it would be unduly cumbersome in extended computation. There is an ample supply of problems, which seem to be well graded as to difficulty. A particularly pleasing feature is the use of many problems which appear in later mathematics courses, for example: setting up of functions such as are used in maximum and minimum problems in the calculus; problems in fractional and negative exponents which are identical with those appearing early in differential calculus. The authors make an attempt to be rigorous within the ability of the student, and when some material is beyond the scope of a beginning text, this is pointed out, with reference to more advanced treatment. It is shown that certain concepts are pure definitions, but an effort is made to show why the particular definition was adopted, as for example in the definition of a zero exponent; zero factorial; or the definition of equality of complex numbers. Alternative notations and methods are mentioned in several places; for some reason there was no mention of two methods of indicating n factorial. The general form and appearance are excellent.

CECIL B. READ, *University of Wichita*

New Practical Mathematics, by N. J. Lennes. Cloth. Pages ix+426. 20×14 cm. 1939. The Macmillan Company, New York, N. Y. Price $1.32.

This is a new book based upon the author's *Practical Mathematics*, more than half of the pages being completely changed. The book is intended for use by high school pupils who take mathematics because of its practical value. There is much arithmetic, a little algebra and some construction geometry. Some of the topics in arithmetic are of interest to restricted groups. For example, there is a section on buying foods that will interest girls more than boys, and there is a section on farm problems

that will interest boys more than girls. A feature of the book is the inclusion of topics for discussion. These are frequently questions based upon the discussions presented in the book. There are frequent tests. The book is illustrated with cartoons.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Mathematics in Daily Life, by Eugene H. Baker, Polytechnic High School, San Francisco, California, and Frank M. Morgan, Director of Clark School, Hanover, New Hampshire. Cloth. Pages vii+432. 20×14 cm. 1939. Houghton Mifflin Company, Chicago. Price $1.32.

This book is for any high school year in which study of the mathematics of daily life is undertaken. No previous mathematics except the usual arithmetic of the first eight school years is taken for granted. The whole book is built around the experiences of the Baxter family and the mathematics they found useful in meeting their needs. These experiences call for some use of simple algebra, some elementary geometry, much arithmetic (including the use of a compound interest table). There is much drill on arithmetic fundamentals, and there are many excellent illustrations. The material would seem to be easy enough for any class of normal pupils.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

Mathematics in Action, Book One, by Walter W. Hart, formerly Associate Professor of Mathematics, School of Education, The University of Wisconsin, and Lora D. Jahn, Vice-principal Junior High School Number One, Trenton, New Jersey. Cloth. Pp. vii+344. 20.5×14.5 cm. 1939. D. C. Heath and Company, Chicago. Price, $.88.

This book is for the seventh school year, and is the first of a two book series. It presents mathematics as found in the probable daily experience of the consumer, and also much of the preliminary work of elementary geometry. During the course many definitions and constructions of geometry are learned. Topics in arithmetic that cause difficulty are carefully presented and recur frequently so that familiarity with them is maintained. Accuracy is encouraged by consistent insistence on checking solutions of problems. A systematic procedure for solving problems is early presented and frequently reviewed as a means of making the pupil think before he begins to manipulate figures. There is an abundance of problems and exercises, and tests are inserted at frequent intervals. There is an abundance of good illustrations.

WALTER H. CARNAHAN, *Shortridge High School, Indianapolis*

RADIUM IN NAVAJO RUGS

Carnotite, canary-yellow colored ore of radium, uranium, and vanadium, is one of the sources of the Indian weavers' black dye, says Dr. Daniel T. O'Connell, geologist of the College of the City of New York, in a report to the journal, *Science*.

Navajos roast yellow carnotite powder in a frying pan until it turns black, then mix with pitch roasted to powder. A third ingredient is a brew from the entire plant of the squaw-berry bush, which must be boiled to a tea-color. The dye is diluted with water.

A good many Navajo weavers now use coal tar dyes, Dr. O'Connell says. But some of the better modern rugs are dyed with the old-time natural dyes, which the Indians themselves concoct from local plant and mineral sources.